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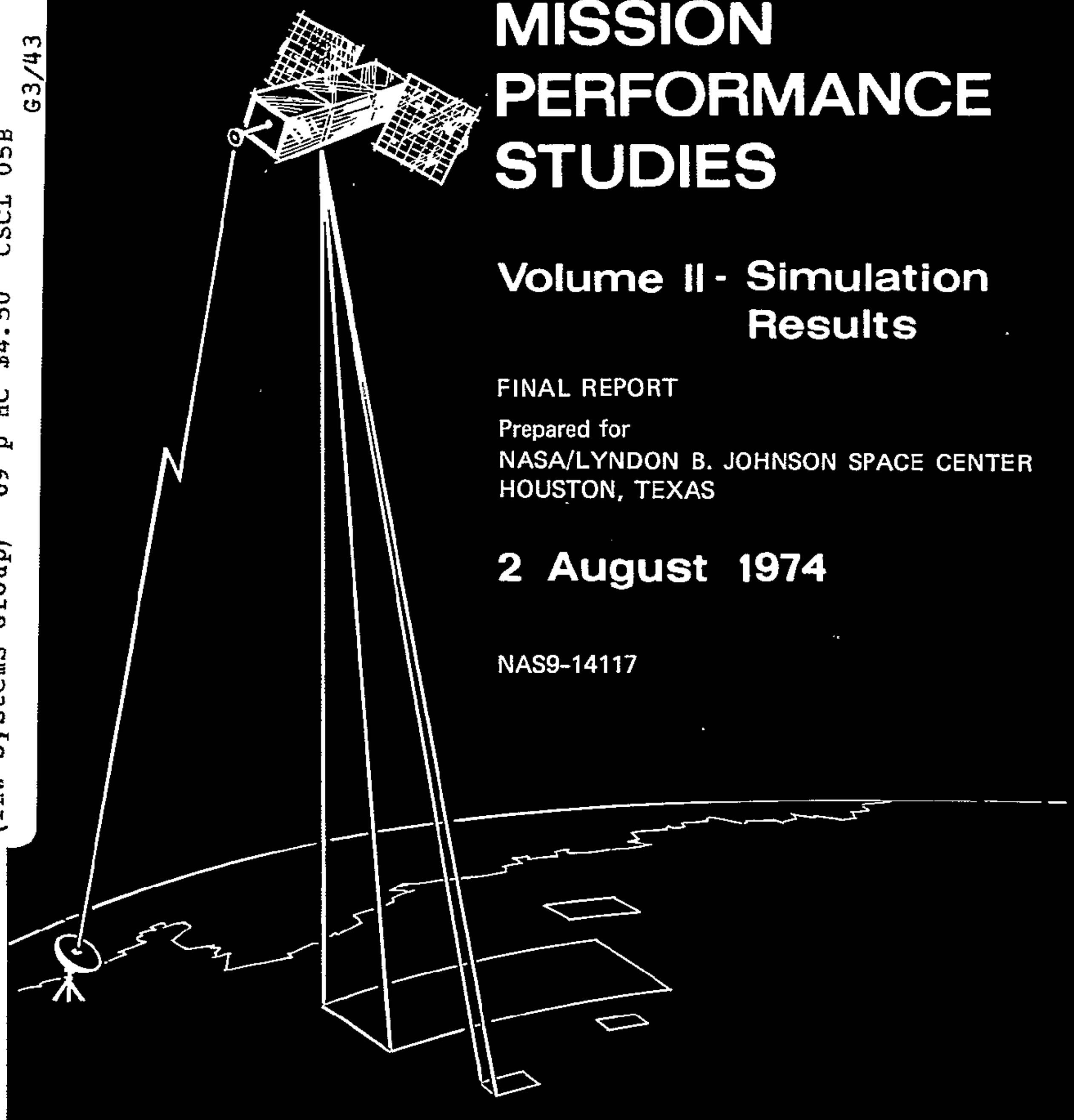

Volume II - Simulation Results

FINAL REPORT

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1.0 INTRODUCTION

It is the purpose of this document to present the analysis of the results developed from a simulation of an EOS mission. A major tool used in this effort was a general purpose Earth Resources mission simulator, which is a computer program developed by TRW under a separate company funded (IR&D) effort. Two sensors were considered in this exercise: (1) the proposed high resolution pointable imager (HRPI), and (2) the multi-spectral thematic mapper. The collection requirements considered in the simulation were compiled and organized as part of this study effort (see Vol. 1, "Requirements Definition"). They included the earth resource applications requirements for the contiguous U.S. land and coastal areas only. The requirements are representative of those desired by the user community, as can be seen at the present time, and are defined in such a way that they express the quantitative goals of the EOS mission.

Four monthly simulations were made in three month intervals to investigate the EOS mission performance over the four seasons of the year. Two basic objectives were desired from this study:

(a) To evaluate the ability of an EOS type system to meet a representative set of specific collection requirements

(b) To understand the capabilities and limitations of the EOS that influence the system's ability to satisfy certain collection objectives

Although the results discussed herein were obtained from a consideration of a two sensor EOS system, the analysis can be applied to any remote sensing system having similar optical and operational characteristics. While the category related results discussed in this report are applicable only to the specified requirement configuration, the results relating to general capability and limitations of the sensors can be applied in extrapolating to other U.S. based EOS collection requirements. The TRW general purpose mission simulator and analytic techniques discussed in this report can be applied to a wide

range of collection and planning problems of earth orbiting imaging systems. This report presents one example of the many possible applications.

2.0 SUMMARY AND CONCLUSIONS

A summary of the major points derived from an analysis of the simulation results is given below.

The simulation results indicated that the 2 sensor EOS configuration can return approximately 500,000 sq. kilometers of cloud free ground scenes of the U.S. (5.6% of contiguous U.S.area) in a given day. This clear coverage rate is more than adequate to meet the set of requirements identified in Volume 1 of this report. The simulation revealed that almost 90 percent of the collection requirements were satisfied.

Slightly over half of the imagery returned by the thematic mapper sensor was obscured by clouds, while only a fifth of that returned by the HRPI sensor was obscured. The improved efficiency of the HRPI sensor is attributable to its ability to point to cloud free areas. The net effect is that the clear coverage rate of HRPI is slightly more than half as much as that of the thematic mapper, even though the HRPI field of view is only a quarter of that of the thematic mapper.

The unique portion of the contiguous U.S. land and coastal areas covered by the 2 sensors in a 30 day period was approximately 80%. However, the simulation indicated twice as much clear imagery of ground scenes was returned in a 30 day period, indicating that some of EOS sites were imaged two or more times in a 30 day period.

The simulation results indicated that the HRPI sensor, as configured in the simulation, can neither perform efficiently against small isolated areas, because of its slow maneuver/settling rate, nor can it perform efficiently against broad areas because of its narrow field of view angle. The slow maneuverability caused the sensor to expend over half of its coverage resource against lessor worth sites. The results indicated also that categories with extended contiguous areas were least satisfied by the HRPI sensor.

The two sensors performed fairly well against the set of collection requirements, but there were a few specific high rate of return categories that were not satisfied. Special attention

should be given to these categories in any future simulation of the EOS missions.

This study was conducted primarily in response to a specific question asked regarding the capability of the EOS sensors, namely, "how well can the EOS system satisfy the category requirements stated in Volume 1, 'Requirements Definition' ?" In the course of the study it became apparent that a complete answer to this question requires an in-depth understanding of all major factors influencing the operations and limitations of the sensors which were outside the scope of this study. It is felt that while a considerable quantity of information was generated from the simulation for the specific configuration studies, but very little is known about performance sensitivity to various control and operating parameters.

Several factors which have a significant influence on performance results were identified during this study and are discussed below. It is recommended that their influence on performance of the sensors be investigated.

Agility of the HRPI Sensor - A parametric study should be initiated to evaluate the effectiveness of the HRPI sensor for various maneuver rates and settling times. The data could be used in optimizing the design of the HRPI sensor configuration.

Mission Parameters and Constraints - A study should be initiated to evaluate the performance sensitivity to various mission parameters and constraints. The mission parameters should include the effect of changing orbital altitude, orbital period (e.g., 14-5/17 vs. 14-9/17 revs/day), launch date and time of day, and weather characteristics. These parameters should be examined for various EOS configurations such as only a thematic mapper, or only an HRPI. The constraint study would examine the influence of activity limitations (e.g., rev, day operations limits) under various levels of collection requirements.

Weather Thresholding - The results described in this report assume that a mosaicing process is used to form a cloud free composite image of a site. Some categories may require that a clear contiguous ground scene be imaged in a single rev. The accomplishment level under such restrictions will be reduced significantly. This process can be simulated and should be investigated.

Variable Scan Mapper - Considerable improvement in performance can be accrued from a variable scan mapper. Such flexibility will allow the sensor to access more sites and to select cloud free sites. A parametric study should be initiated to study such a configuration.

3.0 SIMULATION MODEL

3.1 ORBIT CONFIGURATION

The orbit implemented for this simulation was taken to be circular with a 98.4 degree inclination and vehicle altitude of 714 kilometers (386 n.m.). This resulted in a period of revolution of 98.97 minutes. The orbital injection time was set so that the vehicle would pass over the middle latitude of the United States at around 11:00 a.m. local time.

The longitudinal separation between consecutive revolutions was approximately 24.8 degrees. At 49 degrees latitude near the top of the U.S., this represents about 1807 kilometers (976 n.m.) between revolutions, and at 25 degrees latitude, the bottom of the U.S., the separation is about 2495 kilometers (1347 n.m.). Since the mapper's field of view is 185 kilometers (≈100 n.m.) at the ground from an altitude of 714 kilometers, its percent coverage per rev (field of view at the ground divided by rev separation) varies from about 10 percent to 7 percent from the top to the bottom of the U.S. The HRPI has a ground field of view of 48 kilometers (26 n.m.) so its percent coverage per rev is about one-fourth that of the mapper.

Examination of the orbit revealed that the revolutions for any given day compared to the revs of two days prior were separated by about 2.5 degrees. The patterns are displaced by 2.5 degrees every other day. This displacement is about 181 kilometers (98 n.m.) and 251 kilometers (136 n.m.) at 49 and 25 degrees latitude, respectively. Since the mapper has a field of view at the ground of 185 kilometers (100 n.m.), the mapper coverage swaths for every other day will overlap near the top of the U.S. but will become increasingly separated southward to a maximum of 67 kilometers (36 n.m.) at the bottom of the U.S. The orbital data indicated also that nine days must elapse before the mapper will image the missed areas. The thematic mapper would take only nine days to map the top region of the U.S. completely, but would require seventeen days to cover the remaining part of the United States.

3.2 SENSOR CONFIGURATION

Two sensors, with different imaging characteristics were considered in the present EOS mission simulation. One sensor, called the Thematic Mapper (TM), was considered to be fixed in position relative to the vehicle and pointing in the nadir direction. This sensor has a minimum ground resolution of 30 meters, a spectral range from .5 to 12.6 microns and a field of view covering about 185 kilometers on the ground for the orbital altitude chosen in the study. It was considered to have the capability of stripping continuously along the vehicle ground track for any length of time.

The High Resolution Pointable Imager (HRPI) has a cross-track maneuverability of ± 30 degrees about nadir. The HRPI sensor has a minimum ground resolution of 10 meters, a spectral range from .5 to 1.1 microns, and a field of view on the ground covering about 48 kilometers for the chosen orbital altitude. Like the mapper, the HRPI was considered able to strip out a scene on the ground by utilizing the vehicle orbital motion. The HRPI could strip along the ground track or along any swath parallel to the ground track within a range of 420 kilometers (227 n.m.) either side of the ground track ($\pm 30^{o}$) at the vehicle altitude chosen for the simulation.

The important feature of the HRPI was its capability of maneuvering to selected ground sites. The time required to maneuver through 60 degrees (including settling time) was assumed to be 30 seconds. In this simulation, the effect of the slow maneuver rate of the HRPI sensor was modeled by assuming an average strip duration (about 28 sec.) and an associated maneuver time of 10 sec. between strips. (The HRPI average maneuver will be substantially less than 60 degrees.)

Although both sensors are allowed to operate simultaneously, the image selection process considered the mapper to make the site selections first on a given "pass" over the U.S. followed by the HRPI, both processes being identical in passage time and ground track. On the latter pass, the HRPI was then to select the remaining sites that can be satisfied by that sensor. It should be pointed out that there were no

power constraints whatsoever for either sensor in this simulation. Also, no site was rejected on the basis of critical sun angle, which was taken in this simulation as a minimum 15 degrees above the horizon.

3.3 MISSION PLANNING

A mission planning process was applied in selecting the HRPI operations in order to maximize the utility of the HRPI sensor. Two key functions in the mission planning process were modeled in the simulator. The first is a prioritizing (or weight assignment) scheme which establishes the relative weight of the EOS sites. The second is a rapid selection process which establishes a schedule of operations based on the weights assigned to the site.

3.3.1 Prioritizing Scheme

The purpose of the prioritizing process is to assign weight to the site such that it will cause the sensor to go after the most valuable sites. The weighting process was performed once a day. The weight assigned to a specific site was established based on several factors, including:

1. Coverage frequency or cycle period of the site
2. Cloud-freeness probability of the selected site
3. Accomplishment status of the site (category multiplier)

. Intrinsic worth of the category, to which the site belongs

The total weight received by a site is given by the following expression:

Site Weight = (Cloud-Free Probability) x (Age Weight Factor) x (Category Multiplier) x (Intrinsic Category Worth)

In cases where the site is a member of more than one category, the worth of the site was assumed to be the maximum of the category worths.

3.3.2 Cycle Period Control

To control the resource expended on a site, it is necessary to consider the frequency with which the site must be imaged to meet the data collection requirement. It is desirable that a site is taken only once in its cycle period, and if possible that it be taken on the last day of the cycle period. To accomplish this control, the age of the last observed imagery of the site is used as a basis for establishing the age weight factor of the site. In this simulation, the age factor was set proportional to the ratio of the time since last observation to the cycle period of the site. By this scheme, a site that was taken one month ago and has a required cycle period of a year would receive a factor of 1/12. By such control, a month-old quarterly site would have a greater factor than that of a month-old annual site. The age weight factor is limited to unity at the point when the age of the site imagery equals or exceeds the cycle period.

3.3.3 Cloud Freeness Probability

The chance of a successful observation of an imaged site will depend on the amount of cloud cover existing at the time the imagery was taken. Therefore, sites having less clouds should be selected over those that are cloud covered, assuming all other weighting factors to be equal. To consider this trade, a forecast of the sky clearness over the site, given in eights of clearness, is assumed to be available for planning purposes. By this scheme, a site with a clear forecast of 2/8 would need an otherwise net worth that is three times greater than the net worth of a site that has a clear forecast of 6/8 before it became competitive.

3.3.4 Category Accomplishment Control

It is desirable that the collection accomplishments be balanced among the categories, so that each category receives its planned share of the resources. The category weight factor is used in the simulation to accomplish this. In the simulation, the category weight was adjusted as a function of the accomplishment deviation. The weight was increased for an under-accomplished condition and was decreased for an over-accomplished condition. The weight adjustment was performed once a day and was computed based on daily feedback of accomplishment status. The allowable range of category weight variations was from one-half to five.

3.3.5 Intrinsic (Base) Category Worth

Three classes of categories were defined in this simulation. The first class (M) includes those categories that can be satisfied by the thematic mapper only. The second class (E) includes those categories that can be satisfied by either sensor. The third class (H) includes those categories that can be satisfied by HRPI sensor only. In this series of simulation runs, all categories within each class, i.e., 'M', 'E' and 'H' classes were assumed to have equal priority. However, because of the limited capacity of the HRPI sensor, it was necessary to assign an intrinsic weight to the 'H' class of categories so that they have precedence over the 'E' and 'M' categories. Thus, the 'M', 'E' and 'H' categories received intrinsic weights of 1, 5, and 50, respectively.

3.3.6 Selection Algorithm Modeling

Once the weights of all sites in a rev are established, a selection algorithm is needed in the planning process to select the highest score sites subject to some constraints, such as power limitation, tape recorder capacity, and resource limit. In this simulation no constraints whatsoever for either sensor were used. However, in the case of HRPI, a maneuver penalty was imposed to reflect the wasted time associated with maneuvering from one aim point to another. Thus, the modeling of the HRPI selection process was accomplished by ranking the sites according to their relative worth and then performing the selection based on the relative rank, maneuver capability, and an average strip duration. This process produced a schedule of sensor operations defined by the cross-track point angle, the on-time of the sensor, and a strip duration. The modeling of the selection process for the thematic mapper was accomplished by considering all sites accessed to be selected for imaging.

3.4 ACCOMPLISHMENT BOOKKEEPING

The purpose of the simulator bookkeeping process is to maintain the data necessary for determining the status of the sites and the accomplishment levels of the categories. The basic bookkeeping unit is a 37 x 37 kilometer (20 x 20 n.m.) cell. All sites and areas defined by the requirements are processed in terms of cells. Large areas are broken down by a grid system into the equivalent number of 37 x 37 kilometer cells. Point

sites which are small enough to be completely contained within one cell are treated as single cells. All of the previous discussions of the mission planning process hold for cells as well as sites.

A cell is considered to be imaged in its entirety (400 sq. n.m.) if the center of the cell is accessed within the field of view of the sensor. However, if the imaged cell is partially obscured by clouds, the accomplishment of the cell is considered to be that fraction of the imagery that is clear. If another image of the same cell is taken on subsequent revs, the accomplishment level of the cell is given by

$$\text{Accomplishment} = 1 - (P_{cc})_1 \, (P_{cc})_2$$

The general equation for computing accomplishment is given by

$$\text{Accomplishment} = 1 - (P_{cc})_1 \, (P_{cc})_2 \, (P_{cc})_3 \cdots (P_{cc})_i$$

where

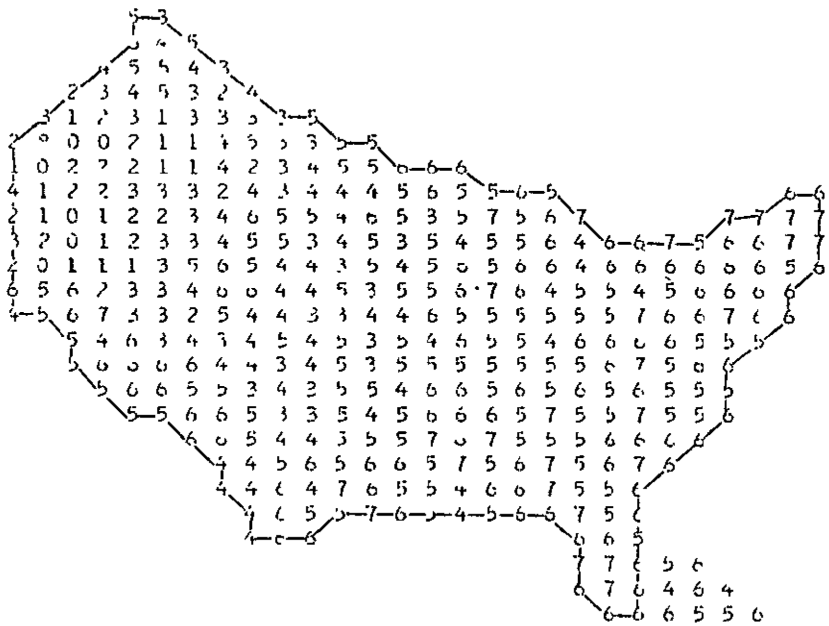
$(P_{cc})_i$ = Fraction of cloud cover contained in the i^{th} image of a cell.

The accomplishment bookkeeping equation assumes that a mosaicking process is used for developing a cloud free composite of the imaged sites. The accomplishment level will be reduced significantly if the imagery of sites is to be completely free of clouds on all selections. The simulator has the capability of only selecting imagery above a specified cloud freeness threshold. This capability was not utilized in this simulation series.

3.5 WEATHER MODEL

Historical weather data was utilized in setting up the weather model for this simulation. This data consisted of percent cloud clearness within 90 x 90 nautical mile grids over the United States for each day of the year. This weather information was compared with data from "Climates of the United States," NOAA, 1973. The mean daily sky cover over various regions of the U. S. for the month of July is given in Figure 1. This figure was extracted from the above source. The comparable data from the simulator historical weather data file is shown in Figure 2. These two figures illustrate the close comparison between the two sources of weather information.

Figure 1. Mean Daily Sky Cover, Sunrise to Sunset, July
(In Tenths)



	Sky Cover		
0	0	-	.1
1	.1	-	.2
2	.2	-	.3
3	.3	-	.4
4	.4	-	.5
5	.5	-	.6
6	.6	-	.7
7	.7	-	.8
8	.8	-	.9
9	.9	-	1.0

Figure 2. Average Sky Cover for Cumulative Periods, July

A close comparison was noted for other months of the year as illustrated by Figure 3. This figure, taken from "Climates of the United States," contains a large number of small graphs positioned at various regions around the United States. The small graphs indicate the percentages of cloud cover for the twelve months of the year (January to December) at those particular regions of the country. Some weather data from the simulator weather file was superimposed upon a few of the small graphs which were blocked out for easy identification. A close comparison between the two sources of weather information is again evident.

3.6 SITE DEFINITION MODEL

The site definition model is based on the area polygons, categories, and requirements defined in Volume 1. Some slight modifications were made to the requirements to reflect the image selection process; however, the total coverage remains the same, (e.g., a 1% coverage for crop yield is simulated as 95% coverage of a specific site equal to 1% of the total crop area.) The site model for the present EOS computer simulation was based primarily on a fixed 37 x 37 kilometer (20 x 20 n.m.) grid of points covering the United States. The various category areas were represented in the model by those sets of grid points falling within their respective boundaries (polygons). Those areas less than the basic 37 x 37 kilometer grid size were modeled simply as point sites centered at their exact geographic locations.

A number of categories, namely, the crop stress categories, required a small percent of uniform sampling throughout certain large geographic areas. The sites making up these categories were chosen at 111 and 148 kilometers (60 and 80 n.m.) apart throughout these large areas for the purpose of obtaining a more uniform sampling coverage in the simulation. Since the simulation was based on 37 x 37 kilometers (20 x 20 n.m.) grid cells, the percent coverage requirement per cycle period for the stress categories had to be modified to reflect the required area coverage with the reduced population in those categories.

Since many category areas overlapped each other, a large number of site points were found to belong to several different categories. To minimize the complexity of the computer program, the multiple category membership per site was limited to ten. This was done by giving

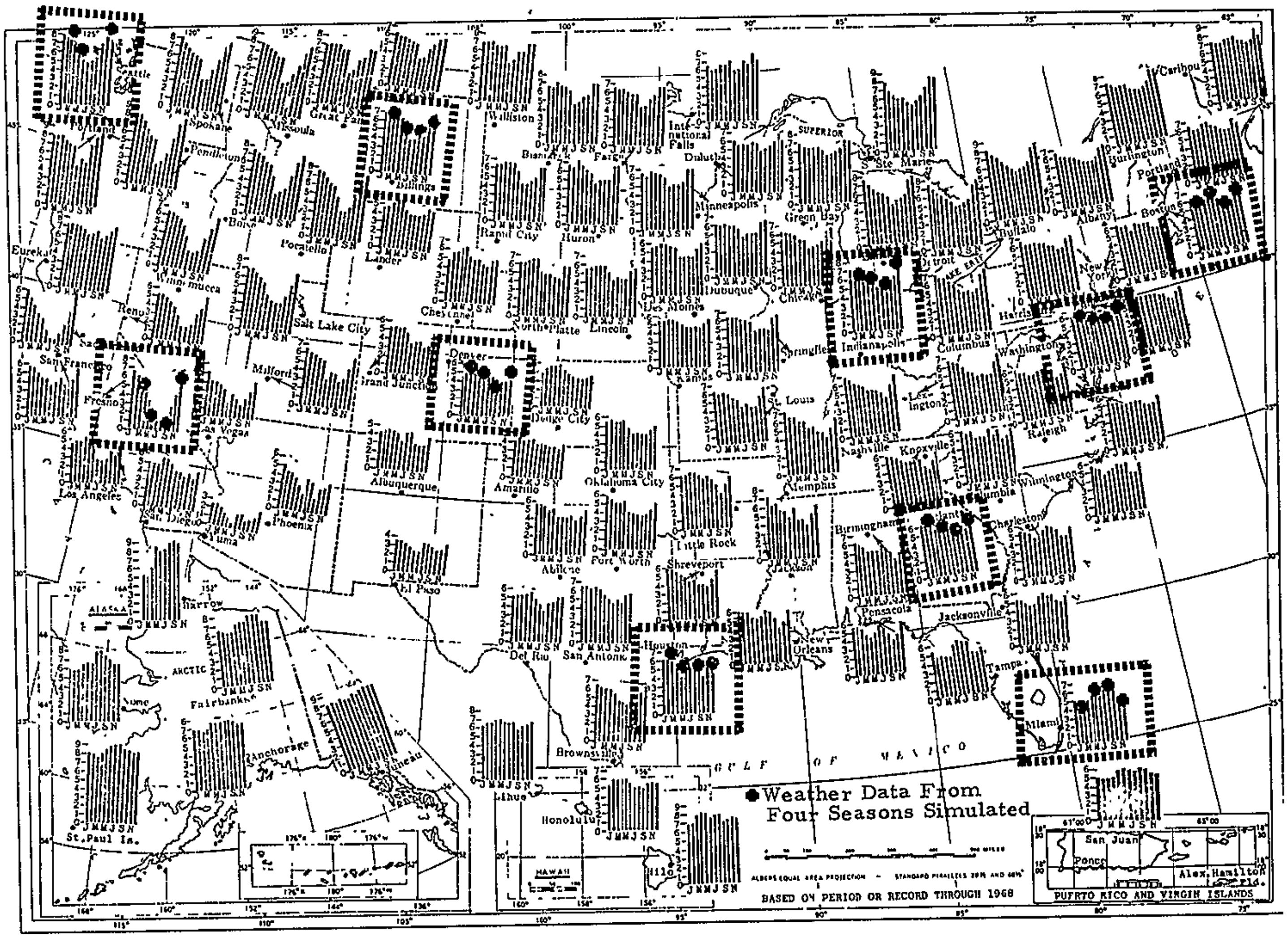


Figure 3. Mean Daily Sky Cover, Sunrise to Sunset, by Months
(In Tenths)

two different computer identification names for each geographical site in the areas where multiple category membership exceeded ten. Also, in order to simplify the computer program operation, the very large category cycle periods were reduced to no greater than 100 days for input to the program. The daily required return rate for these categories was maintained at the correct level by reducing (in the proper proportion) their coverage percentages required per cycle period and the number of site points in the categories. The latter was achieved by uniformly deleting the proper number of site points for the categories in question.

3.7 REQUIREMENT SUMMARY

The final category requirements used in the simulation are presented in Table 1. The category number and name appear on the left side of the table. A basic requirement of each category is to image a certain percentage (PN) of the category area under clear weather conditions within a specified time period (NC). The column of values under the heading "%-Area Required Per Cycle Period" are the percentages (PN) for each of the 111 categories. Their corresponding time periods (NC) are listed in the next column of data under the heading "Cycle Period." The values in the next column of data tabulate the total number of cells in each category. The category classification is indicated next in the table. This information defines a specific category as belonging to class "M" (mapper), class "H" (HRPI), or to class "E" (either).

Many of the categories defined in this study have seasonal requirements which means that they are required to be imaged only during certain periods of time. Table 1 indicates those categories that were active during the months chosen for the present simulations. The next to the last and the last columns of data in the table are the daily required return and the daily required area percentage, respectively. The daily required return is the percentage (PN) of each category times its number of cells divided by its cycle period (NC). The daily required area percentage is the category percentage (PN) divided by its cycle period (NC).

Table 1. Simulation Category Requirements

CATEGORY NUMBER	CATEGORY NAME	% - AREA REQUIRED PER CYCLE PERIOD	CYCLE PERIOD (DAYS)	NUMBER OF SITES	SENSOR			MONTH ACTIVE				DAILY REQUIRED RETURN (SITES/DAY)	PERCENT AREA REQUIRED PER DAY
					TM	HRPI	EITHER	JUNE	SEPT.	DEC.	MAR.		
1	SPRING WHEAT INVENTORY	80	90	243			●	●				2.160	.889
2	SPRING WHEAT YIELD	90	30	4		●		●				.120	3.000
3	SPRING WHEAT STRESS	26	14	25		●		●				.464	1.857
4	WINTER WHEAT INVENTORY (NORTH & NW)	80	90	97			●	●	●			.862	.889
5	WINTER WHEAT YIELD (NORTH & NW)	90	30	3		●		●				.090	3.000
6	WINTER WHEAT STRESS (NORTH & NW)	25	14	11		●		●				.196	1.786
7	WINTER WHEAT INVENTORY (MIDWEST – ROCKY)	80	90	597			●	●	●			5.307	.889
8	WINTER WHEAT YIELD (MIDWEST – ROCKY)	90	30	9		●		●				.270	3.000
9	WINTER WHEAT STRESS (MIDWEST – ROCKY)	25	14	68		●		●	●			1.214	1.786
10	CORN INVENTORY (EASTERN & MIDWEST)	80	90	525			●	●	●			4.667	.889
11	CORN YIELD (EASTERN & MIDWEST)	90	30	9		●		●	●			.270	3.000
12	CORN STRESS (EASTERN & MIDWEST)	26	14	60		●		●	●			1.114	1.857
13	CORN INVENTORY (SOUTH EASTERN)	80	90	125			●	●	●			1.111	.899
14	CORN YIELD (SOUTH EASTERN)	90	30	3		●		●	●			.090	3.000
15	CORN STRESS (SOUTH EASTERN)	26	14	13		●		●	●			.241	1.857
16	RICE INVENTORY	80	90	73			●	●	●			.649	.889
17	RICE YIELD	80	30	4		●		●	●			.107	2.667
18	RICE STRESS	27	14	8		●		●	●			.154	1.929
19	SOYBEANS INVENTORY	80	90	695			●	●	●			6.178	.889
20	SOYBEANS YIELD	90	30	11		●		●	●			.330	3.000
21	SOYBEANS STRESS	27	14	75		●		●	●			1.446	1.929
22	COTTON INVENTORY (EASTERN)	80	90	496			●	●	●			4.409	.889
23	COTTON YIELD (EASTERN)	90	30	8		●		●	●			.240	3.000
24	COTTON STRESS (EASTERN)	27	14	55		●		●	●			1.061	1.929
25	COTTON INVENTORY (WESTERN)	80	90	148			●	●	●			1.316	.889
26	COTTON YIELD (WESTERN)	90	30	3		●		●	●			.090	3.000
27	COTTON STRESS (WESTERN)	26	14	17		●		●	●		●	.316	1.857
28	TOBACCO INVENTORY	80	90	222			●	●	●			1.973	.889
29	TOBACCO YIELD	90	30	5		●		●	●			.150	3.000
30	TOBACCO STRESS	27	14	25		●		●	●			.482	1.929
31	CITRUS INVENTORY (SOUTH EASTERN)	80	100	82			●	●	●			.656	.800
32	CITRUS YIELD (SOUTH EASTERN)	80	30	3		●		●	●			.080	2.667
33	CITRUS STRESS (SOUTH EASTERN)	46	30	9		●		●	●			.138	1.533
34	CITRUS INVENTORY (WESTERN)	80	100	137			●	●	●			1.096	.800
35	CITRUS YIELD (WESTERN)	90	30	3		●		●	●			.090	3.000
36	CITRUS STRESS (WESTERN)	49	30	14		●		●	●			.229	1.633
37	GRASSLANDS INVENTORY/STRESS	80	30	1209			●	●	●			32.213	2.667
38	GRASSLANDS STRESS MONITOR	48	14	75		●		●	●	●	●	2.571	3.429
39	SOIL WETLANDS SURVEY	90	90	5826			●	●	●	●	●	58.260	1.000
40	SOIL WETLANDS MOISTURE AREAS	90	30	1208	●			●	●	●	●	36.240	3.000
41	SOIL WETLANDS MOISTURE SITES	50	14	30	●			●	●	●	●	1.071	3.571
42	EASTERN CONIFER FOREST INVENTORY	71	100	276			●	●	●	●	●	1.960	.710
43	EASTERN CONIFER FOREST TIMBER YIELD	45	100	3		●		●	●	●	●	.014	.450
44	EASTERN CONIFER FOREST STRESS	45	30	54		●		●	●			.810	1.500
45	EASTERN CONIFER FOREST FIRE CONDITION	80	30	805	●			●		●		21.467	2.667
46	WESTERN CONIFER FOREST INVENTORY	71	100	243			●	●	●	●	●	1.725	.710
47	WESTERN CONIFER FOREST TIMBER YIELD	39	100	3		●		●	●	●	●	.012	.390
48	WESTERN CONIFER FOREST STRESS	49	30	43		●		●	●			.702	1.633
49	WESTERN CONIFER FOREST FIRE CONDITION	80	30	705	●			●	●			18.800	2.667
50	HARDWOOD FOREST INVENTORY	71	100	211			●	●	●	●	●	1.498	.710
51	HARDWOOD FOREST TIMBER YIELD	45	100	4		●		●	●	●	●	.018	.450
52	HARDWOOD FOREST STRESS	52	30	35		●		●	●			.607	1.733
53	HARDWOOD FOREST FIRE CONDITIONS	80	30	607	●			●		●		16.187	2.667
54	MIXED FOREST INVENTORY	71	100	57			●	●	●	●	●	.405	.710
55	MIXED FOREST TIMBER YIELD	22	100	2		●		●	●	●	●	.004	.220

FOLDOUT FRAME

FOLDOUT FRAME 2

CATEGORY NUMBER	CATEGORY NAME	% - AREA REQUIRED PER CYCLE PERIOD	CYCLE PERIOD (DAYS)	NUMBER OF SITES	SENSOR			MONTH ACTIVE				DAILY REQUIRED RETURN (SITES/DAY)	PERCENT AREA REQUIRED PER DAY
					TM	HRPI	EITHER	JUNE	SEPT.	DEC.	MAR.		
56	MIXED FOREST STRESS	54	30	9		●		●	●			.162	1.800
57	MIXED FOREST FIRE CONDITIONS	80	30	163	●			●		●		4.347	2.667
58	RAIN PRECIPITATION (JAN, FEB, MAR)	25	7	2585	●						●	92.321	3.571
59	RAIN PRECIPITATION (APR, MAY, JUNE)	25	7	2139	●			●				76.393	3.571
60	RAIN PRECIPITATION (JUL, AUG, SEP)	25	7	2669	●				●			95.286	3.571
61	RAIN PRECIPITATION (OCT, NOV, DEC)	25	7	259	●					●		9.250	3.571
62	SNOW (NOV – MAR)	25	7	880			●				●	31.429	3.571
63	SNOW (DEC – FEB)	25	7	2938			●			●		104.929	3.571
64	SNOW (JAN)	25	7	3377			●					120.607	3.571
65	PHYSIOGRAPHIC MAPPING EASTERN	100	100	132	●			●	●	●	●	1.320	1.000
66	PHYSIOGRAPHIC MAPPING SOUTHEASTERN	100	100	227	●			●	●	●	●	2.270	1.000
67	PHYSIOGRAPHIC MAPPING MIDWESTERN	100	100	237	●			●	●	●	●	2.370	1.000
68	PHYSIOGRAPHIC MAPPING GULF	100	100	245	●			●	●	●	●	2.450	1.000
69	PHYSIOGRAPHIC MAPPING ROCKY MOUNTAIN	100	100	222	●			●	●	●	●	2.220	1.000
70	PHYSIOGRAPHIC MAPPING SOUTHWESTERN	100	100	124	●			●	●	●	●	1.240	1.000
71	PHYSIOGRAPHIC MAPPING NORTHERN	100	100	128	●			●	●	●	●	1.280	1.000
72	PHYSIOGRAPHIC MAPPING INTERMOUNTAIN	100	100	132	●			●	●	●	●	1.320	1.000
73	PHYSIOGRAPHIC MAPPING CALIFORNIA	100	100	87	●			●	●	●	●	.870	1.000
74	PHYSIOGRAPHIC MAPPING PACIFIC NW	100	100	91	●			●	●	●	●	.910	1.000
75	URBAN TRANSPORTATION (PILOT SITES)	84	100	15		●		●	●	●	●	.126	.840
76	IRON INVENTORY	51	100	34			●	●	●	●	●	.173	.510
77	IRON MONITOR	90	90	9		●		●	●	●	●	.090	1.000
78	COPPER INVENTORY	72	100	124			●	●	●	●	●	.893	.720
79	COPPER MONITOR	90	90	9		●		●	●	●	●	.090	1.000
80	NICKEL MONITOR	84	100	4		●		●	●	●	●	.034	.840
81	EASTERN COAL INVENTORY	84	100	104			●	●	●	●	●	.874	.840
82	EASTERN COAL MONITOR	90	90	3		●		●	●	●	●	.030	1.000
83	WESTERN COAL INVENTORY	84	100	204			●	●	●	●	●	1.714	.840
84	WESTERN COAL MONITOR	90	90	3		●		●	●	●	●	.030	1.000
85	EASTERN OIL AND GAS INVENTORY	84	100	93			●	●	●	●	●	.781	.840
86	EASTERN OIL AND GAS MONITOR	91	100	2		●		●	●	●	●	.018	.910
87	WESTERN OIL AND GAS INVENTORY	84	100	453			●	●	●	●	●	3.805	.840
88	WESTERN OIL AND GAS MONITOR	91	100	6		●		●	●	●	●	.055	.910
89	URANIUM INVENTORY	72	100	117			●	●	●	●	●	.842	.720
90	URANIUM MONITOR	80	90	13		●		●	●	●	●	.116	.889
91	GEOTHERMAL INVENTORY	100	100	6809	●							68.090	1.000
92	GEOTHERMAL MONITOR	83	100	71	●			●	●	●	●	.589	.830
93	HYDROLOGY SURFACE WATER INVENTORY	100	100	6809	●							68.090	1.000
94	HYDROLOGY SURFACE WATER MONITOR	70	30	485		●		●	●	●	●	11.317	2.333
95	HYDROLOGY GLACIERS MONITOR	100	90	8	●			●	●	●	●	.089	1.111
96	EASTERN COASTLINE (BOTTOM TOPO)	50	90	253	●			●	●		●	1.406	.556
97	EASTERN COASTLINE (CIRCULATION)	20	7	253		●		●	●	●	●	7.229	2.857
98	EASTERN COASTLINE (CONSTRUCTION)	95	90	4		●		●	●	●	●	.042	1.056
99	FLORIDA COASTLINE (BOTTOM TOPO)	80	90	106	●			●	●	●	●	.942	.889
100	FLORIDA COASTLINE (CIRCULATION)	30	7	106		●		●	●	●	●	4.543	4.286
101	FLORIDA COASTLINE (CONSTRUCTION)	95	90	1		●		●	●	●	●	.011	1.056
102	GULF COASTLINE (BOTTOM TOPO)	50	90	157	●			●	●	●	●	.872	.556
103	GULF COASTLINE (CIRCULATION)	20	7	157		●		●	●	●	●	4.486	2.857
104	GULF COASTLINE (CONSTRUCTION)	95	90	3		●		●	●	●	●	.032	1.056
105	PACIFIC COASTLINE (BOTTOM TOPO)	50	90	197	●			●	●	●	●	1.094	.556
106	PACIFIC COASTLINE (CIRCULATION)	20	7	197		●		●	●	●	●	5.629	2.857
107	PACIFIC COASTLINE (CONSTRUCTION)	95	90	2		●		●	●	●	●	.021	1.056
108	GREAT LAKES (BOTTOM TOPO)	80	90	260	●			●	●		●	2.311	.889
109	GREAT LAKES ICE	95	7	20		●				●		2.714	13.571
110	MAJOR ESTUARIES/WETLANDS	80	7	217		●		●	●	●	●	24.800	11.429
111	RIVER DISCHARGES	94	100	47		●		●	●	●	●	.442	.940

The daily required area percentage reflects the daily fraction of the category's area that must be imaged cloud free in order to meet the category collection requirements. A category having a high daily area percentage requirement would need a corresponding level of daily cloud free accesses for all its sites. If, because of weather or orbital constraints, the frequency of cloud free accesses were less than the required area percentage per day, the specified collection requirement of the category would not be met. In this respect, it can be seen from Table 1 that there are a few categories with requirements difficult to satisfy, notably categories 109 and 110. The requirements of these two categories are at a level which demand a daily area percent imagery greater than 10 percent. This requirement is equivalent to stating that the areas must be completely imaged 100 percent cloud free in ten days. This is practically impossible to achieve due to the usual cloudy conditions prevailing from day to day and also due to the difficulty of completely accessing the area in ten days.

Four thirty-day computer simulations were run at the different seasons of the year. The months simulated were June, September, December, and March. A rigorous analysis was made of the various overall requirements for the four simulation months. The results are summarized in Table 2. The number of unique cells in each class is the total number of cells belonging to each class of categories active for that month. Cells belonging to two or more categories of the same class are counted only once in the summation. These totals represent the number of cells available for imagery during those months for each of the three classifications of categories. The average number of cells in each class is the previous number of unique cells divided by the number of active categories in each class. It can be observed from these statistics that the "H" categories are generally small and have dispersed cells, while the "M" and "E" categories are large and have large contiguous areas.

On the basis of the stated requirements, it is possible to determine the minimum number of cells that must be imaged each day (under a perfect environment) to meet the stated requirements of the various active categories. This minimum number of cells per day requirement is termed "unique return rate" and was computed for each of the three classifications of categories for each of the four simulation months. The results are tabulated in Table 2. Additional computations were made to determine

the unique return rate for the TM sensor alone (class "M" and class "E" categories) and the HRPI sensor alone (class "H" and class "E" categories). This data is found at the bottom of Table 2.

From this table, it is evident that the mass of the required site points over the U. S. belong to the "M" and "E" categories. This is reflected in the daily required return rate for the three classes of categories. The mapper return rate is seen to be about twice that of the HRPI sensor, with the class "E" return rate falling between the two, except for the month of December when the class "E" return rate is largest.

The required return rate for the mapper operating alone exceeds that for the HRPI operating alone except for December, which is a month of low active categories. This data, at the bottom of Table 2, must be considered as the minimum return rate for an EOS system containing a TM sensor alone or an HRPI sensor alone but not both and represents the return rate requirements for these two different and limited capabilities. The two sensors together must return a minimum of 220 clear cells per day (average). If it is not possible for the sensors to operate successfully at this return rate, then the requirements can never be satisfied.

Both categories 91 and 93 completely cover the United States, and the sum of the areas of categories 65 through 74 includes the entire U. S. and all of these categories have the same requirements. It was therefore decided to inactivate categories 91 and 93 during all four months simulated because accomplishment of categories 65 through 74 constitutes accomplishment of categories 91 and 93. This reduced the category area overlap which facilitated the makeup of the site definition model. Accomplishment for categories 91 and 93 can be obtained from the regional accomplishment of categories 65 through 74.

None of the four months considered in this simulation represent the actual start of the mission in the sense that all categories were initially overdue. At the start of each of the four simulation runs, the age distributions of all those categories active for the month under consideration, as well as for the previous month, were initialized such that the categories were in a steady state condition at the start of the first day of the run. The age distributions of those categories that became active at the beginning of the month under consideration were initialized all overdue at the start of the run.

Table 2. Requirements Summary

	MAR	JUN	SEPT	DEC	Aver.
NUMBER OF ACTIVE CATEGORIES	59	101	92	60	78
Number of Unique Cells in:					
Class M Categories	4943	5351	5155	4214	4916
Class E Categories	5965	6041	6041	6079	6032
Class H Categories	1346	1711	1635	1366	1515
Average Number of Cells in:					
Class M Category	247	332	245	201	256
Class E Category	426	496	252	468	411
Class H Category	54	42	35	53	46
Unique Return Rate (Cell/Day) Required by:					
Class M Categories	134	141	143	99	129
Class E Categories	82	80	80	136	95
Class H Categories	54	62	60	57	58
Thematic Mapper Return Rate (Cells/Day) Needed to Satisfy the 'M' and 'E' Categories	158	154	158	177	162
HRPI Return Rate (Cells/Day) Needed to Satisfy the Class 'H' and 'E' Categories	126	127	126	181	140
HRPI and Thematic Mapper Return Rate (Cells/Day) Needed to Satisfy 'M', 'E', 'H' Categories	212	216	218	234	220

4.0 MISSION PERFORMANCE ANALYSIS

4.1 SENSOR PERFORMANCE

Several measurands were used to evaluate the sensor performance characteristics. These performance measurands reflect a measure of the sensor's general capability in terms of coverage and efficiency, as well as the sensor's ability to access and image any specified cell. The sensor performance measurands include:

1. Coverage Return. The amount of cloudy and clear ground area imaged by the sensor in a day.
2. Cloud Freeness Efficiency. The expected fraction of cloud-free (clear) imagery in the total imagery returned by the sensor.
3. Clear Coverage Rate. The amount of clear area returned by the sensor in a day.
4. Select/Access Ratio. The fraction of accessed area selected by the sensor for imaging.
5. Acquisition Rate. The expected percent of times in which a site will be accessed, selected, and imaged under a clear sky condition on a random day.

A summary of the first three performance measurands is shown in Table 3 for the four seasons simulated.

4.1.1 Coverage Return

This measurand reflects the amount of the sensor system capacity that was actually employed against the cell model in the simulation. The coverage return of the sensor, defined to be the total imagery returned in a day, is generally dependent upon the field of view of the sensor and any on/off time constraints associated with the sensor operations. Inasmuch as no on/off time constraint was imposed on sensor operations in these simulations, the amount of returned coverage is dependent only on the viewing range of the sensor, and the physical locations of the EOS

Table 3. Sensor Performance Comparison for Various Seasons

	HRPI					TM				
PERFORMANCE PARAMETER	MAR	JUN	SEPT	DEC	Aver.	MAR	JUN	SEPT	DEC	Aver.
COVERAGE RETURN (10^4 SQ. N. M. PER DAY)	6.7	6.6	6.7	6.7	6.7	22.1	22.2	22.3	21.4	22.3
CLOUD FREENESS EFFICIENCY	.74	.82	.83	.75	.78	.35	.44	.50	.37	.42
CLEAR COVERAGE RATE (10^4 SQ. N. M. PER DAY)	5.0	5.4	5.5	5.0	5.2	7.7	9.8	11.4	7.8	9.18
TOTAL RETURN RATE (CELLS PER DAY)	125	136	137	126	131	193	245	284	196	230

sites. In the case of the thematic mapper, the sensor stripped continuously from border to border on all orbit passes over the U.S., which occurred about two and one-half times per day. This daily operation produced approximately 752,000 sq. kilometers (220,000 sq. n.m.) of imagery. This is equivalent to approximately 550 cells (20 n.m. x 20 n.m.) per day or about 8 percent of the EOS sites. Since the distributions of the EOS sites for the four seasons are fairly similar, the coverage return of the thematic mapper, as shown by the simulation results, remained fairly constant throughout the simulation year.

Because of the wider access range of the pointable sensor, the HRPI sensor had more active revs and longer period of potential operations, hence more imaging opportunities than the thematic mapper. However, the field of view of the HRPI sensor is only a quarter of that of the thematic mapper. The additional opportunities available to HRPI increased its coverage return slightly from a nominal of 25 percent to 30 percent of the thematic mapper coverage. The simulation results showed an average HRPI return of approximately 168 cells per day. This coverage rate included the coverage loss associated with maneuvering between operations.

4.1.2 Cloud-Freeness Efficiency

Cloud-freeness efficiency is one of several indicators which describe the value of the returned imagery. Inasmuch as the selection for the thematic mapper operations was uncontrolled, the cloud-freeness efficiency of the thematic mapper was driven by weather. A comparison of the thematic mapper cloud-freeness efficiency against the sky clearness statistics indicates a close match between the fraction of imagery that is clear and the average fraction of clear sky over the U.S. This indicates that insofar as the thematic mapper is concerned, the quantity of clear return is predictable within the accuracy of forecasting the amount of clear sky. Therefore, based on the U.S. climatic data, it is expected that the thematic mapper in mapping the U.S. sites will have cloud-free efficiencies ranging from a low of 35 percent in the winter months to a high of 50 percent in the summer months.

The HRPI cloud-freeness efficiency is expected to exceed that of the thematic mapper because of its ability to point to clear EOS sites. As noted in the comparison table, the improvement in efficiency is as much

as a factor of two. The relative cloud-freeness efficiency between the two sensors will vary with seasons, the largest difference to be anticipated in adverse weather months.

A plot showing a comparison of the efficiencies for the two sensors against the average frequency of clear sky over the U.S. is presented in Figure 4.

4.1.3 Clear Coverage Rate

Clear coverage rate provides a measure as to how much clear imagery is returned in a day by the sensor. A summary of the HRPI and thematic mapper clear coverage rates is shown in Table 3. The results show that HRPI is able to return slightly over half as much clear imagery as the thematic mapper while having a coverage capacity of only 30 percent of the thematic mapper. The quantity of clear imagery returned by HRPI on an average day is about 131 cells per day, and 230 cells per day by the thematic mapper.

4.1.4 Select/Access Ratio

This measurand describes the amount of accessed area that can be selected by the sensor, and thus reflects the degree of freedom the sensor has in selecting the most valuable site for imaging. In the case of the thematic mapper, all sites accessed on a rev were selected and resulted in a select/access ratio of unity. The simulation results indicated a select/access ratio for HRPI of .063, indicating that about one out of sixteen candidate cells was selected for imagery.

4.1.5 Acquisition Rate

The ability of the sensor to acquire a cloud-free image of a cell on a random day is expressed by the acquisition rate of the sensor. It is a measure of how well the sensor can satisfy a collection requirement. The factors that are included in this measurand include:

1. Access rate: The ability of the sensor system to access the cell.

2. Select/access ratio: The quantity of accessed cells that can be imaged.

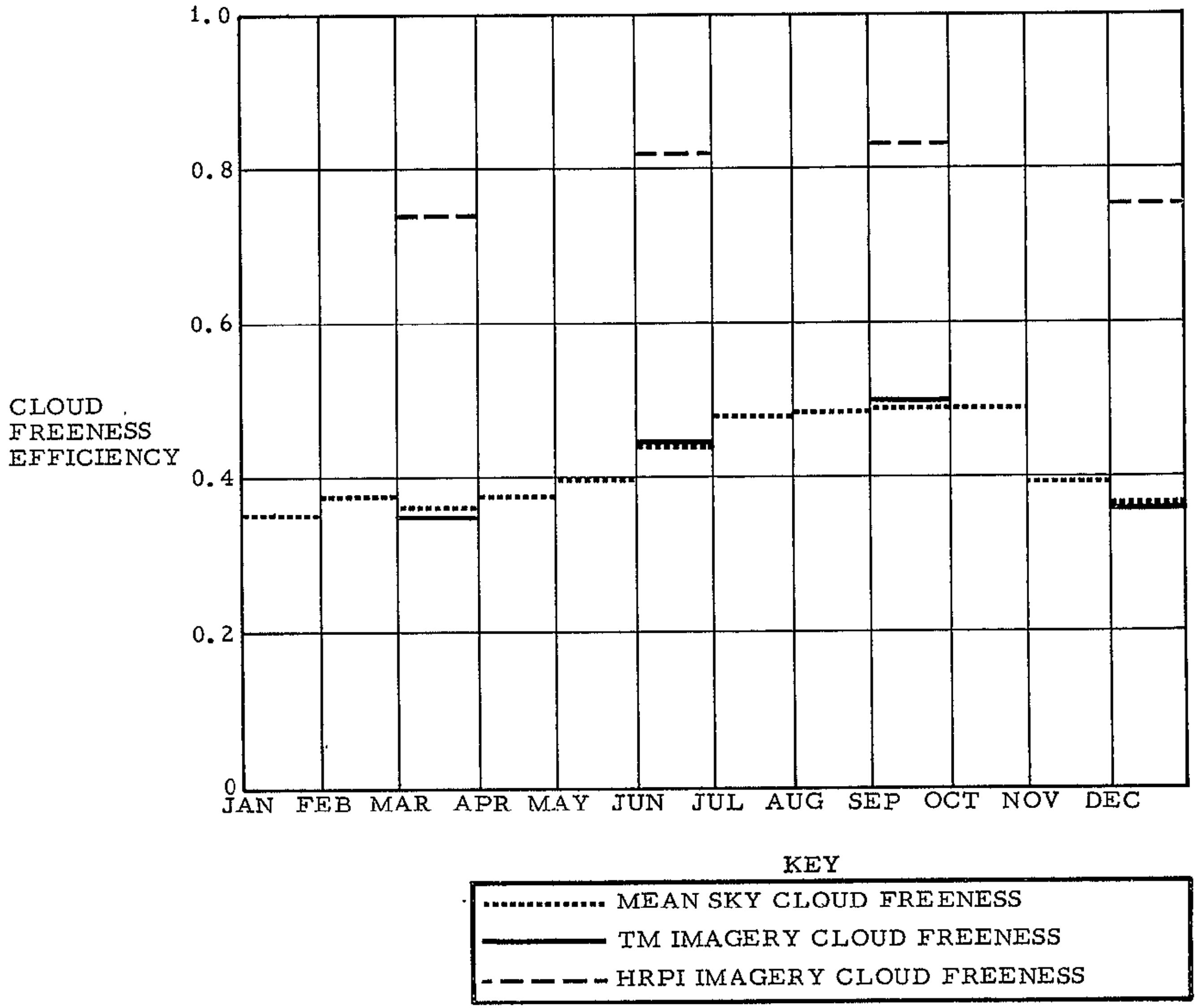


Figure 4. Seasonal Comparison of Cloud-Freeness Efficiencies

3. Cloud-freeness efficiency: The probability of clear imagery, given the cell was accessed and imaged.

The acquisition rate of the sensor is given by the following expression:

$$(\text{Acquisition Rate}) = (\text{Access Rate}) \times (\text{Select/Access Ratio}) \times (\text{Cloud-Freeness Efficiency})$$

Table 4 shows typical acquisition rate values observed in the simulation runs. The results indicated an average acquisition rate for a typical EOS site is about .019 for the HRPI sensor and .034 for the thematic mapper. The acquisition rate of .019 means that a nominal EOS site will have a .019 probability (a 1.9% chance) of being accessed and imaged successfully on a random day. The acquisition rate will, of course, vary with different sites (or categories) since access rate, climatology and select/access ratio are regional peculiar parameters. It is interesting to point out that the maximum values of acquisition rate observed in the simulation runs were .08 for HRPI and .062 for the thematic mapper. These values are of interest since they represented the limiting acquisition rates of the sensors for the environment simulated, and are indicative of the sensor's ability to meet the collection requirements. For example, the collection requirements of a category requiring a daily percentage return which is greater than the maximum sensor acquisition rate (e.g., 8% or greater for HRPI category) can not be satisfied in the environment simulated.

4.2 RESOURCE UTILIZATION

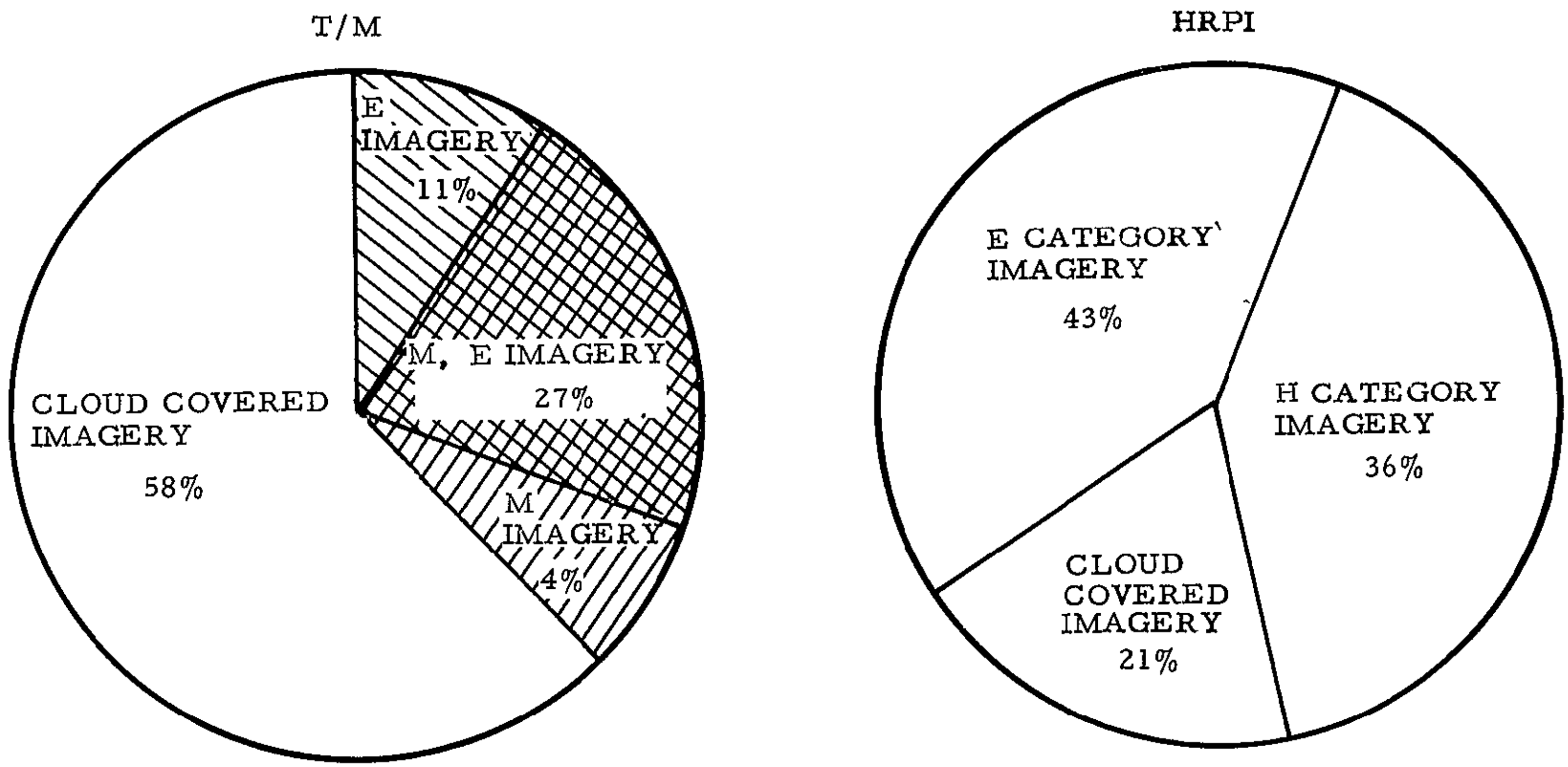
This section describes how the resources were expended in satisfying the collection objectives. Resources as used herein refer to the available imaging time over the sites. In terms of sensor coverage rate, the available resource of the sensor was 550 and 168 cells per day for the thematic mapper and HRPI, respectively.

4.2.1 HRPI Resources

Figure 5 shows how the HRPI resources were divided between the "E" and "H" categories. The results show that the "H" categories received an average of 36 percent of the HRPI available resources, while the "E" categories received 43 percent. The remainder (21%) was

Table 4. Typical Sensor Acquisition Rates Observed From Simulation Run

	HRPI				THERMATIC MAPPER			
PERFORMANCE PARAMETER	MAR	JUN	SEPT	DEC	MAR	JUN	SEPT	DEC
AVERAGE SELECT/ACCESS RATE	.064	.062	.062	.063	1.00	1.00	1.00	1.00
AVERAGE ACCESS RATE	.389	.391	.389	.390	.083	.083	.083	.083
AVERAGE CLOUD FREENESS EFFICIENCY	.74	.82	.83	.75	.35	.44	.50	.37
AVERAGE ACQUISITION RATE	.018	.020	.020	.019	.029	.036	.042	.029
MAXIMUM ACQUISITION RATE	.080	.076	.065	.080	.040	.057	.062	.045



% OF IMAGERY TAKEN AT VARIOUS SKY COVER LEVELS

	SKY COVER LEVEL								
	$\frac{0}{8}$	$\frac{1}{8}$	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$	$\frac{8}{8}$
HRPI	36	21	16	10	7	5	3	2	0
THEMATIC MAPPER	13	9	6	8	7	9	10	15	23

Figure 5. Distribution of Sensor Resources

expended on cloud covered scenes. It was not the intention in this simulation to apply that much HRPI resources against the "E" categories, as the weight of the "H" categories was set in a way that it always dominated the selection. An analysis of the results indicated that the unusual high percentage of "E" consumption was caused by either of the following situations:

1. There were no other "H" cells to take, so "E" cells were chosen.
2. The operation, initiated by "H" cells, was extended in lieu of wasting the resource through maneuvering to another "H" cell, thereby picking up "E" cells as "bonus."

The latter characteristic accounted for approximately 95 percent of the operations and is attributable to the slow maneuver rate of the HRPI sensor. Increased agility will certainly provide better control of resource utilization, enabling the system to apply more resources to preferred sites.

Approximately 21 percent of the imagery returned by HRPI was covered with clouds. The amount of cloud obscuration in the HRPI imagery is summarized in Table 5 for the four seasons. Note that close to 83 percent of the imagery has less than 3/8 cloud cover.

4.2.2 Thematic Mapper Resources

Figure 5 also presents the distribution of the thematic mapper resources expenditure. The cloud-covered portion of the imagery accounted for 58 percent of the thematic mapper resources. The useful portion (42 percent) was shared between "M" and "E" categories, with 27 percent directed toward satisfaction of common "M" and "E" cells, 11 percent toward exclusive "E" cells, and 4 percent toward exclusive "M" cells.

The amount of clouds in the thematic mapper imagery is summarized in Table 6 for the four seasons. Note that only 28 percent (compared to 83 percent for HRPI) of the imagery had less than 3/8 cloud cover, indicating in most cases, mosaicking of the thematic mapper imagery is required to obtain a cloud-free composite of a given area.

Table 5. Distribution of Obscured Imagery from HRPI Sensor

SEASON	PERCENT OF IMAGERY TAKEN AT VARIOUS SKY COVER LEVELS SKY COVER LEVEL								
	$\frac{0}{8}$	$\frac{1}{8}$	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$	$\frac{8}{8}$
MARCH	26	22	18	11	9	8	3	3	0
JUNE	44	20	13	11	5	4	1	2	0
SEPT	44	25	12	7	4	3	3	2	0
DEC	30	18	19	12	9	6	3	3	0
COMPOSITE	36	21	16	10	7	5	3	2	0

Table 6. Distribution of Obscured Imagery from Thematic Mapper

SEASON	PERCENT OF IMAGERY TAKEN AT VARIOUS SKY COVER LEVELS — SKY COVER LEVELS								
	$\frac{0}{8}$	$\frac{1}{8}$	$\frac{2}{8}$	$\frac{3}{8}$	$\frac{4}{8}$	$\frac{5}{8}$	$\frac{6}{8}$	$\frac{7}{8}$	$\frac{8}{8}$
MARCH	8	8	6	7	6	9	10	17	29
JUNE	14	8	5	8	10	11	11	13	20
SEPT	19	10	8	8	8	10	11	14	12
DEC	9	8	6	8	6	8	9	16	30
COMPOSITE	13	9	6	8	7	9	10	15	23

4.2.3 Comparison Against Required Resources

Earlier discussions (Section 3.7) indicated that the "M" class of categories requires an average return rate of 129 cells per day to meet its collection goals, while the "E" class of categories requires an average of 95 cells per day and the "H" class of categories requires an average of 58 cells per day. These requirements are compared against the actual resources expended against each class of categories in Figure 6. The minimum return rate needed to achieve the observed category accomplishment levels is also present in the figure. The comparison indicates that over 33% additional resources (above the minimum required) were expended against the "M" class of categories by the thematic mapper and 18% above what was expended on the "M" categories was spent on the "E" class of categories, while the resources received by the "H" categories match closely what was required. The HRPI resource, not applied to any "H" categories was expended on the "E" categories, resulting with the "E" categories receiving more than 142% over their minimum required resource. The significance of this comparison is that considerable amounts of superfluous resources were expended on the "E" categories. This additional expenditure does not contribute to increasing the level of the accomplishment; it merely adds redundancy to the coverage of the cells, indicating some cells were taken more often than the desired frequency.

4.3 CATEGORY SATISFACTION

There are two key performance measurands used in evaluating how well the collection requirements were satisfied. The collection requirements are specified in terms of ".... A (PN) percentage of the area in a category must be imaged cloud-free at least once every (NC) days." Consistent with this specification, one performance measurand is defined as:

> Category Accomplishment - Fraction of the area in a category that was imaged cloud-free at least once in the last (NC) days.

Category accomplishment is measured once a day, since the status is continuously changing with updating and aging of the cells during the mission.

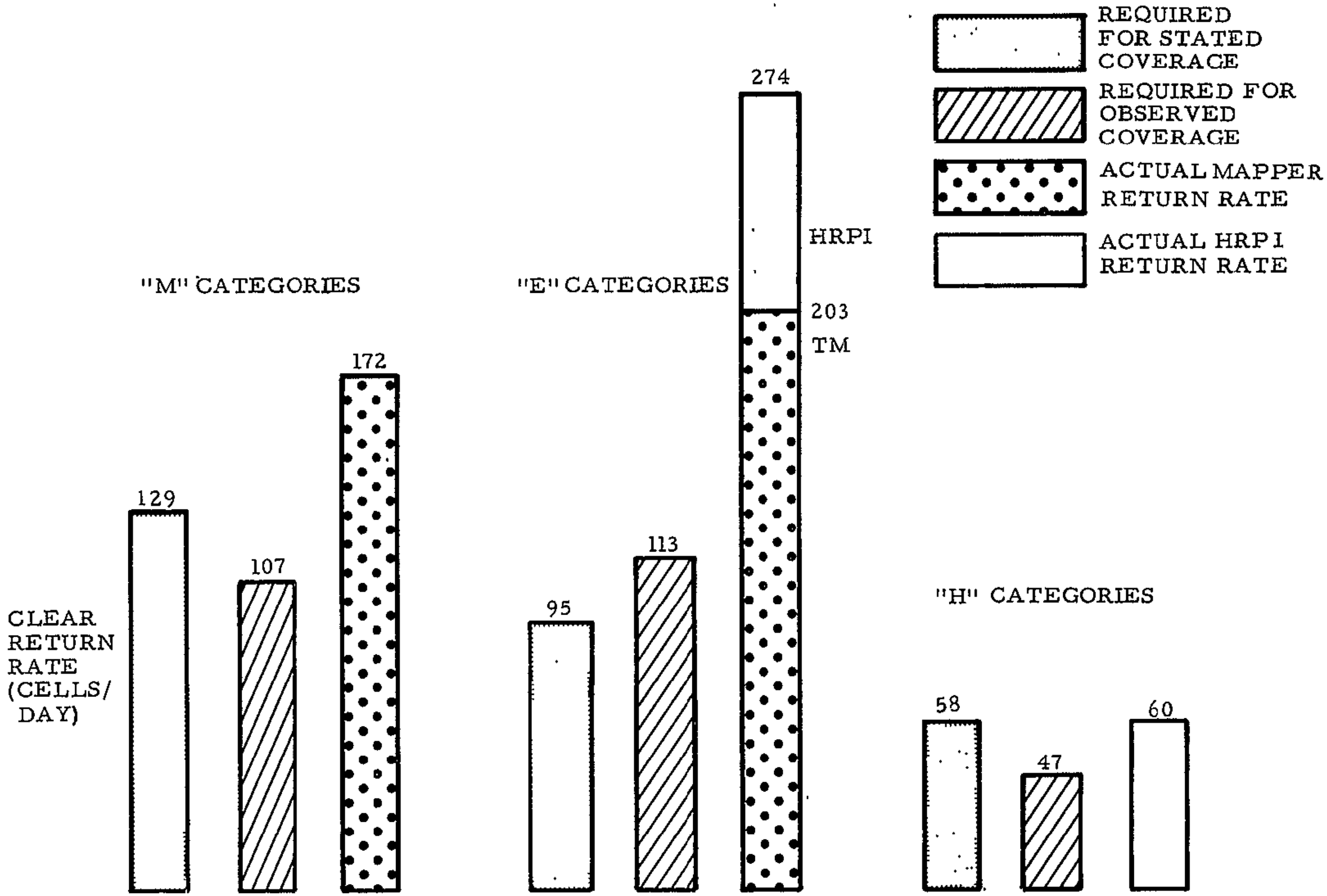


Figure 6. Resource Utilization Efficiency

The other performance measurand, referred to as category satisfaction ratio, provides a relative measure of how well the requirement was satisfied. It is defined as:

> Category Satisfaction Ratio (CSR) - Ratio of the average category accomplishment to the required category accomplishment (PN).

Since it is assumed that over-accomplishment does not provide any additional information, the category satisfaction ratio is limited to unity.

Table 7 presents the expected value of category satisfaction ratio for the "M", "E", and "H" classes of categories for the four simulation seasons. It can be seen that average CSR values of .88, .99 and .91 were noted for "M", "E" and "H" classes of categories, respectively. The worst category satisfaction ratio was observed in December for the "M" categories, since the "M" requirements were the heaviest while the clear coverage rate was the lowest for that time of the year. The best category satisfaction ratio was observed in September for the "E" categories. The "E" categories also showed the best overall average performance level, with "M" and "H" categories showing comparable performance levels. This is consistent with the "E" categories having received the most resources (Figure 6).

Table 7 also shows the unique portion of the contiguous U. S. land and coastal areas covered by the 2 sensors in a 30 day period. It can be seen that more unique areas were seen in September than the other months.

The distribution of the category satisfaction ratios for the "M", "E" and "H" groupings of categories is illustrated in Figures 7-10 for March, June, September and December, respectively. The corresponding CSR data are summarized in Tables 8-10. The data in these tables are not truncated at unity to show the amount of over-accomplishment achieved.

4.3.1 Causes of Performance Deficiency

There are several reasons why some categories failed to meet category requirement goals. Some of these causes are as follows:

Impossible Daily Percentage Return - One potential reason for deficiency in accomplishment level can be attributed to the severity of

Table 7. Category Satisfaction Comparison

PERFORMANCE PARAMETER	SEASON				
EXPECTED CATEGORY SATISFACTION RATIO (Each Category of Equal Value)	MARCH	JUNE	SEPT.	DEC.	AVERAGE
CLASS M	.85	.90	.94	.83	.88
E	.98	.99	1.00	.99	.99
H	.91	.89	.93	.89	.91
FRACTIONS OF CONTIGUOUS U. S. SEEN AT LEAST ONCE IN 30 DAYS (FROM BOTH SENSORS)	.74	.82	.87	.74	.79

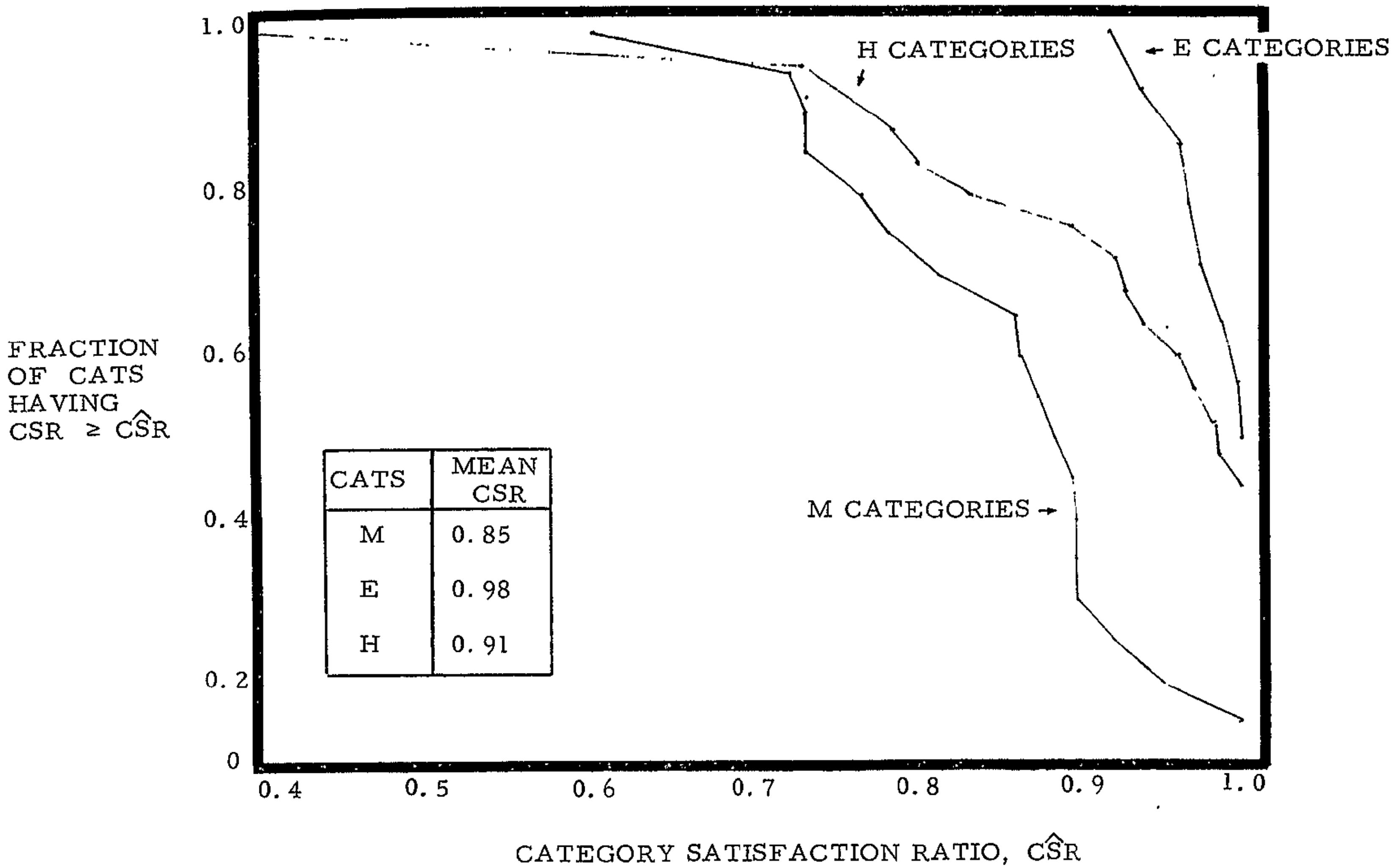


Figure 7. Category Satisfaction Distribution (March Simulation)

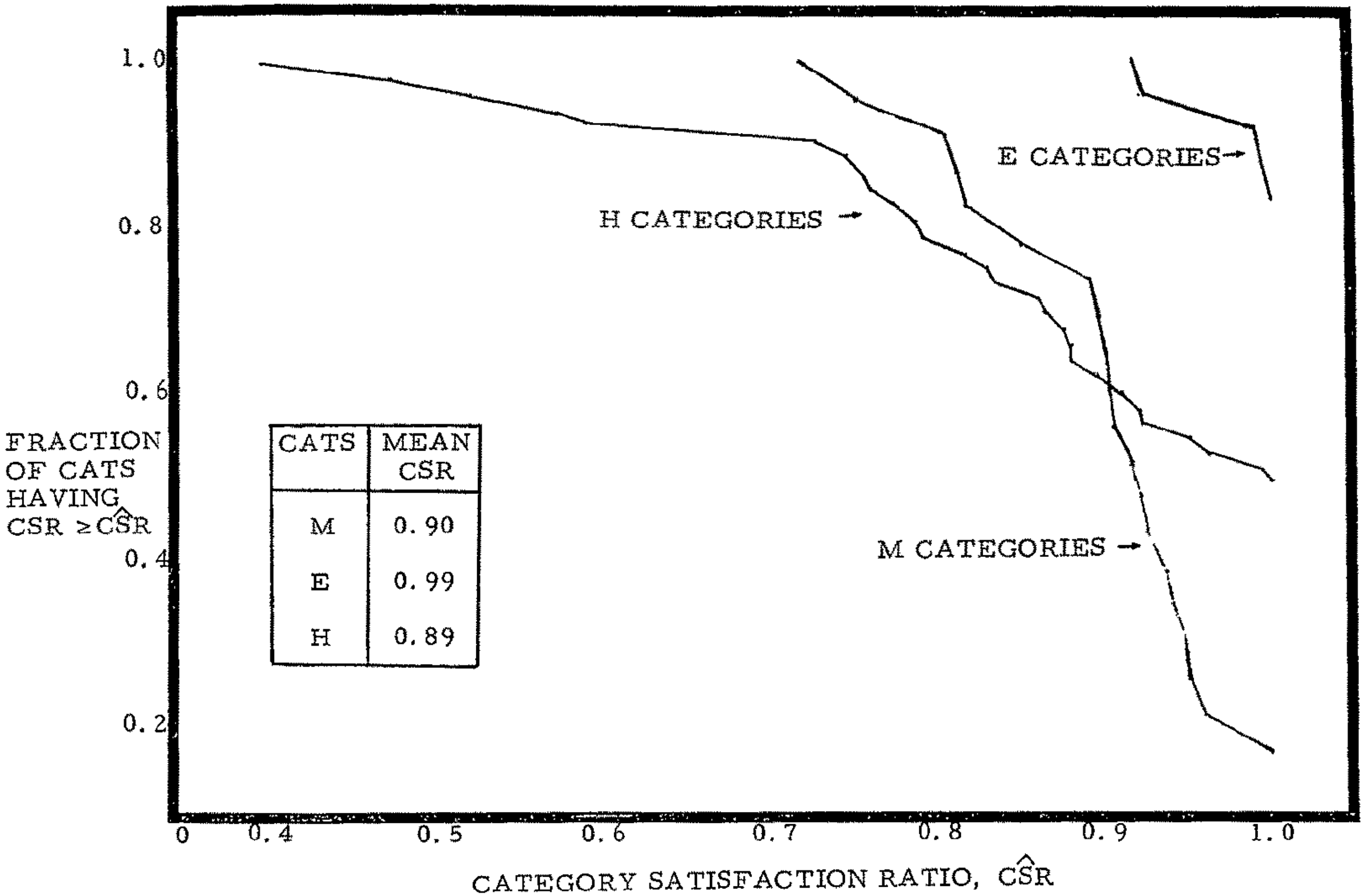


Figure 8. Category Satisfaction Distribution (June Simulation)

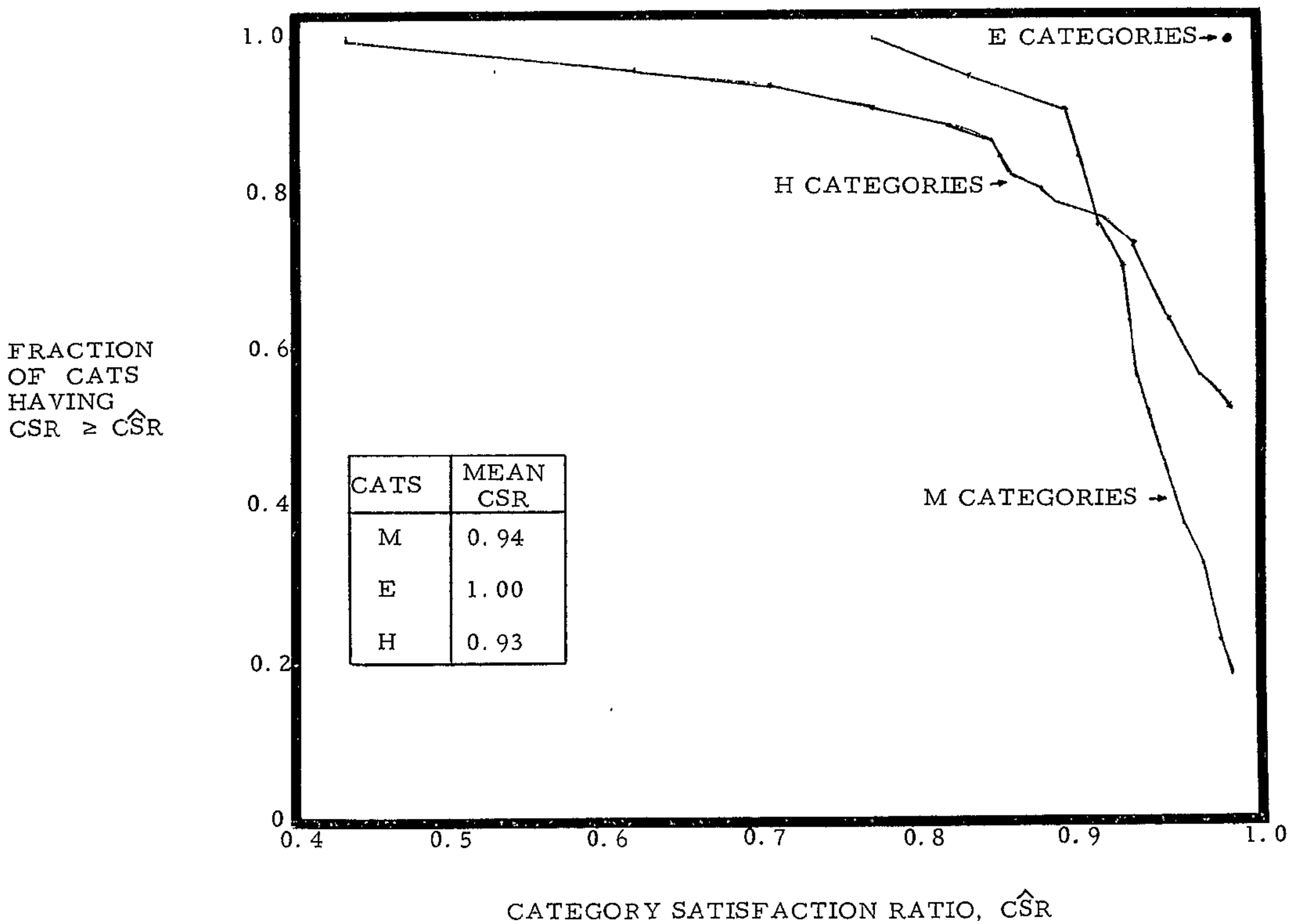
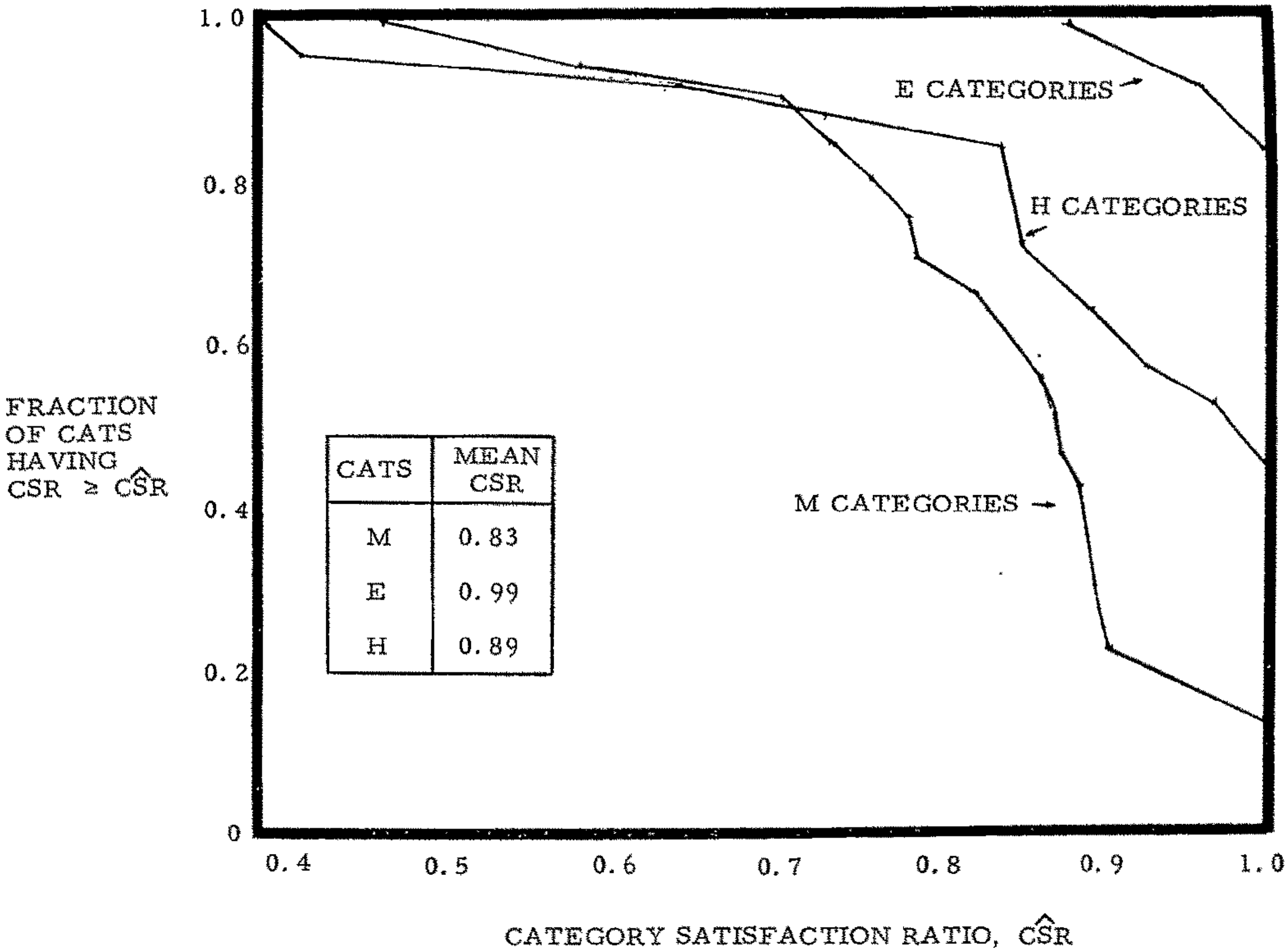


Figure 9. Category Satisfaction Distribution (September Simulation)



CATS	MEAN CSR
M	0.83
E	0.99
H	0.89

Figure 10. Category Satisfaction Distribution (December Simulation)

Table 8. Summary of Category Satisfaction Ratios (M Categories)

CAT	DESCRIPTION	REQUIRED PERFORMANCE	CSR RATIO			
			MARCH	JUNE	SEPT	DEC
40	Soil Wetlands Moisture Areas	90	.732	.803	.833	.704
41	Soil Wetlands Moisture Sites	50	.724	.902	.934	.880
45	Eastern Conifer Forest Fire Cond.	80	-	.811	-	.788
49	Western Conifer Forest Fire Cond.	80	-	-	.999	-
53	Hardwood Forest Fire Conditions	80	-	.716	-	.759
57	Mixed Forest Fire Conditions	80	-	.848	-	.784
58	Rain Precipitation (Jan, Feb, Mar)	25	.732	-	-	-
59	Rain Precipitation (Apr, May, Jun)	25	-	.816	-	-
60	Rain Precipitation (Jul, Aug, Sep)	25	-	-	.952	-
61	Rain Precipitation (Oct, Nov, Dec)	25	-	-	-	.460
65	Physiographic Mapping Eastern	100	.865	.926	.949	.886
66	Physiographic Mapping Southeastern	100	.875	.891	.915	.871
67	Physiographic Mapping Midwestern	100	.883	.904	.933	.897
68	Physiographic Mapping Gulf	100	.898	.901	.926	.888
69	Physiographic Mapping Rocky Mtn	100	.898	.938	.955	.906
70	Physiographic Mapping Southwestern	100	.887	.917	.904	.906
71	Physiographic Mapping Northern	100	.863	.924	.900	.877
72	Physiographic Mapping Intermountain	100	.898	.961	.969	.863
73	Physiographic Mapping California	100	.922	.939	.978	.897
74	Physiographic Mapping Pacific NW	100	.813	.894	.939	.823
92	Geothermal Monitor	83	.954	1.034	1.136	1.027
95	Hydrology Glacier Monitor	100	.768	.949	.896	.823
96	Eastern Coastline (Bottom Topo)	50	1.226	1.448	1.666	-
99	Florida Coastline (Bottom Topo)	80	1.106	.948	1.008	1.058
102	Gulf Coastline (Bottom Topo)	95	.783	.748	.770	.737
105	Pacific Coastline (Bottom Topo)	50	1.804	1.664	1.874	1.760
108	Great Lakes (Bottom Topo)	80	.601	1.031	.981	-

Table 9. Summary of Category Satisfaction Ratios (E Categories)

CAT	DESCRIPTION	REQUIRED PERFORMANCE	CSR RATIO			
			MARCH	JUNE	SEPT	DEC
1	Spring Wheat Inventory	80	-	.994	-	-
4	Winter Wheat Inventory	80	-	1.063	1.053	-
7	Winter Wheat Inventory (Midw-Rocky)	80	-	1.116	1.014	-
10	Corn Inventory (Eastern and Midwest)	80	-	1.021	1.150	-
13	Corn Inventory (Southeastern)	80	-	1.124	1.163	-
16	Rice Inventory	80	-	1.061	1.151	-
19	Soybeans Inventory	80	-	1.096	1.164	-
22	Cotton Inventory (Eastern)	80	-	1.101	1.130	-
25	Cotton Inventory (Western)	80	-	1.023	1.119	-
28	Tobacco Inventory	80	.919	1.088	1.161	-
31	Citrus Inventory (South Eastern)	80	-	1.001	1.148	-
34	Citrus Inventory (Western)	80	-	1.023	1.095	-
37	Grasslands Inventory/Stress	80	-	.920	1.008	-
39	Soil Wetlands Survey	90	.964	1.006	1.014	.960
42	Eastern Conifer Forest Inventory	71	1.261	1.234	1.256	1.248
46	Western Conifer Forest Inventory	71	1.251	1.273	1.318	1.231
50	Hardwood Forest Inventory	71	1.247	1.203	1.279	1.209
54	Mixed Forest Inventory	71	1.207	1.197	1.282	1.296
62	Snow (Nov - Mar)	25	.936	-	-	-
63	Snow (Dec - Feb)	25	-	-	-	.876
76	Iron Inventory	51	1.733	1.559	1.831	1.673
78	Copper Inventory	72	1.238	1.258	1.275	1.250
81	Eastern Coal Inventory	84	.968	.919	1.052	1.002
83	Western Coal Inventory	84	.975	1.001	1.095	1.055
85	Eastern Oil and Gas Inventory	84	.998	.991	1.018	1.058
87	Western Oil and Gas Inventory	84	.988	1.042	1.080	1.056
89	Uranium Inventory	72	1.188	1.244	1.256	1.253

Table 10. Summary of Category Satisfaction Ratios (HRPI Categories)

CAT	DESCRIPTION	REQUIRED PERFORMANCE	CSR RATIO			
			MARCH	JUNE	SEPT	DEC
2	Spring Wheat Yield	90	-	1.033	-	-
3	Spring Wheat Stress	26	-	1.677	-	-
5	Winter Wheat Yield (North and NW)	90	-	.861	-	-
6	Winter Wheat Stress(North and NW)	25	-	1.596	-	-
8	Winter Wheat Yield (Midwest-Rocky)	90	-	.880	-	-
9	Winter Wheat Stress (Midwest-Rocky)	25	-	1.116	-	-
11	Corn Yield (Eastern & Midwest)	90	-	.951	1.106	-
12	Corn Stress (Eastern & Midwest)	26	-	1.419	1.273	-
14	Corn Yield (South Eastern)	90	-	.571	.996	-
15	Corn Stress (South Eastern)	26	-	1.100	.962	-
17	Rice Yield	80	-	1.041	1.073	-
18	Rice Stress	27	-	1.019	1.615	-
20	Soybeans Yield	90	-	1.007	.846	-
21	Soybeans Stress	27	-	1.033	1.144	-
23	Cotton Yield (Eastern)	90	-	.587	1.068	-
24	Cotton Stress (Eastern)	27	-	.726	.774	-
26	Cotton Yield (Western	90	-	1.019	1.053	-
27	Cotton Stress (Western)	26	-	1.154	.854	-
29	Tobacco Yield	90	-	.774	.818	-
30	Tobacco Stress	27	-	.878	.944	-
32	Citrus Yield (South Eastern)	80	-	.755	1.041	-
33	Citrus Stress (South Eastern)	46	-	.759	1.609	-
35	Citrus Yield (Western)	90	-	.746	.938	-
36	Citrus Stress (Western)	90	-	.471	.620	-
38	Grasslands Stress Monitor	48	.929	.790	.979	1.013
43	Eastern Conifer Forest Timber Yield	45	1.389	1.573	1.358	2.222
44	Eastern Conifer Forest Stress	45	-	1.078	1.011	-
47	Western Conifer Forest Timber Yield	39	2.454	1.567	1.139	2.123

Table 10. Summary of Category Satisfaction Ratios (HRPI Categories) (Continued)

CAT	DESCRIPTION	REQUIRED PERFORMANCE	CSR RATIO			
			MARCH	JUNE	SEPT	DEC
48	Western Conifer Forest Stress	49	-	1 545	1 214	-
51	Hardwood Forest Timber Yield	45	1.458	1.331	.927	1.649
52	Hardwood Forest Stress	52	-	.787	889	-
55	Mixed Forest Timber Yield	22	4.214	4.264	3.032	1 896
56	Mixed Forest Stress	54	-	1.589	1.357	-
75	Urban Transportation (Pilot Sites)	84	1.042	1.092	1.056	1.049
77	Iron Monitor	90	1.078	1.096	1.070	1.003
79	Copper Monitor	90	.834	.880	.969	.893
80	Nickel Monitor	84	1.191	1.191	1.191	1.191
82	Eastern Coal Monitor	90	.987	.864	.864	1.096
84	Western Coal Monitor	90	.787	.910	.949	.896
86	Eastern Oil & Gas Monitor	91	.962	.962	1.031	.733
88	Western Oil & Gas Monitor	91	.801	.893	1.076	.865-
90	Uranium Monitor	80	1.080	1.110	1.000	.970
94	Hydrology Surface Water Monitor	70	.924	.834	1.009	.853
97	Eastern Coastline (Circulation)	20	1.405	1.135	1.270	1.235
98	Eastern Coastline (Construction)	95	.972	.831	1.008	.843
100	Florida Coastline (Circulation)	30	.733	.520	.617	.640
101	Florida Coastline (Construction)	95	.987	.921	.921	.965
103	Gulf Coastline (Circulation)	20	.730	.815	.705	835
104	Gulf Coastline (Construction)	95	1.045	.994	.877	1.038
106	Pacific Coastline (Circulation)	20	1.660	1.745	1.510	1.505
107	Pacific Coastline (Construction)	95	.939	1.003	.938	.844
109	Great Lakes Ice	95	-	-	-	.410
110	Major Estuaries/Wetlands	90	.386	.394	.434	.391
111	River Discharges	94	.896	.923	.961	.928

the requirement. The requirement may be at a level in which the daily percentage return (percent of a category that must be covered in a day) is impossible to achieve due to limitations in access rate (orbit constraint) and weather conditions. Examples of categories having this characteristic are categories 109 and 110. Their average daily percentage return rates are 13.6 percent and 11.4 percent for 109 and 110, respectively. It is apparent by comparing them against the average acquisition rate of 2 percent for the HRPI sensor that these categories will be difficult to satisfy. The simulation data indicates these categories achieved half of the required daily percentage return rate.

Impossible Return Rate - The inability of the sensor to achieve the requirement goal can be caused by overloading of requirements within a localized region. The required return rate in a region may exceed the imaging capacity of the sensor system. This situation occurs when: (1) there is a concentration of several categories in the region, and (2) the requirement level of a category requires an extremely high return rate. An example of such a region is in the southern and Florida Gulf coastline. Within that region, categories 100, 103 and 110 were competing for the sensor resources. In addition, the orientation of the polygons of these categories is normal to HRPI stripping direction, which further restricted the coverage of these categories. As a result, these categories showed a perennial deficiency in their accomplishment levels.

Adverse Weather - Failure to meet the goals of some categories can be attributed to unfavorable weather. An example of this is exhibited by category 61, "rain precipitation." This category is located in the Pacific Northwest, and requires a daily percentage return of 3.6 percent in the month of December. The weather data indicates that the Pacific Northwest region at that time of year has cloud covered sky approximately 80 percent of the time, which exceeds what is required to achieve the required daily percentage return rate. It is estimated that at least a clear sky frequency of 40 percent was needed to achieve the required return rate.

4.4 ACCOMPLISHMENT PROFILE

Typical accomplishment profiles are presented in Figures 11-15. The typical plots were selected to illustrate the following characteristics of the accomplishment profile.

- Figure 11 illustrates the accomplishment for a typical "M" category whose coverage requirement is set at 100 percent. Because of the high coverage level required, the requirement was not met. However, the system was able to maintain category satisfaction ratio at about .96.

- Figure 12 illustrates the accomplishment level for a category whose coverage requirement was satisfied. The accomplishment remained fairly constant at the desired level throughout the simulation period. This profile indicates that the sensor was able to acquire sufficient new imagery to make up for those which have aged beyond the cycle period.

- Figure 13 illustrates the accomplishment for a category which failed to meet its requirements by a significant amount. Note that the initial status was at .74; however, because the aging rate of the cells exceeded the acquisition rate of the sensor, the accomplishment gradually dropped until an equilibrium condition is reached, after which it stabilized at a level of about half of what is required.

- Figure 14 illustrates the accomplishment for a category having no prior imagery at the start of the simulation period. It can be seen from this illustration the sensor collected sufficient imagery within 7 days to satisfy the stated requirement, and was able to maintain that level of accomplishment.

- Figure 15 illustrates the accomplishment from a category having very few cells as member of the category. The plot shows discrete changes in accomplishment level as cells become overdue and as cells are acquired. For such categories, one should expect to see considerable fluctuations in the accomplishment profile.

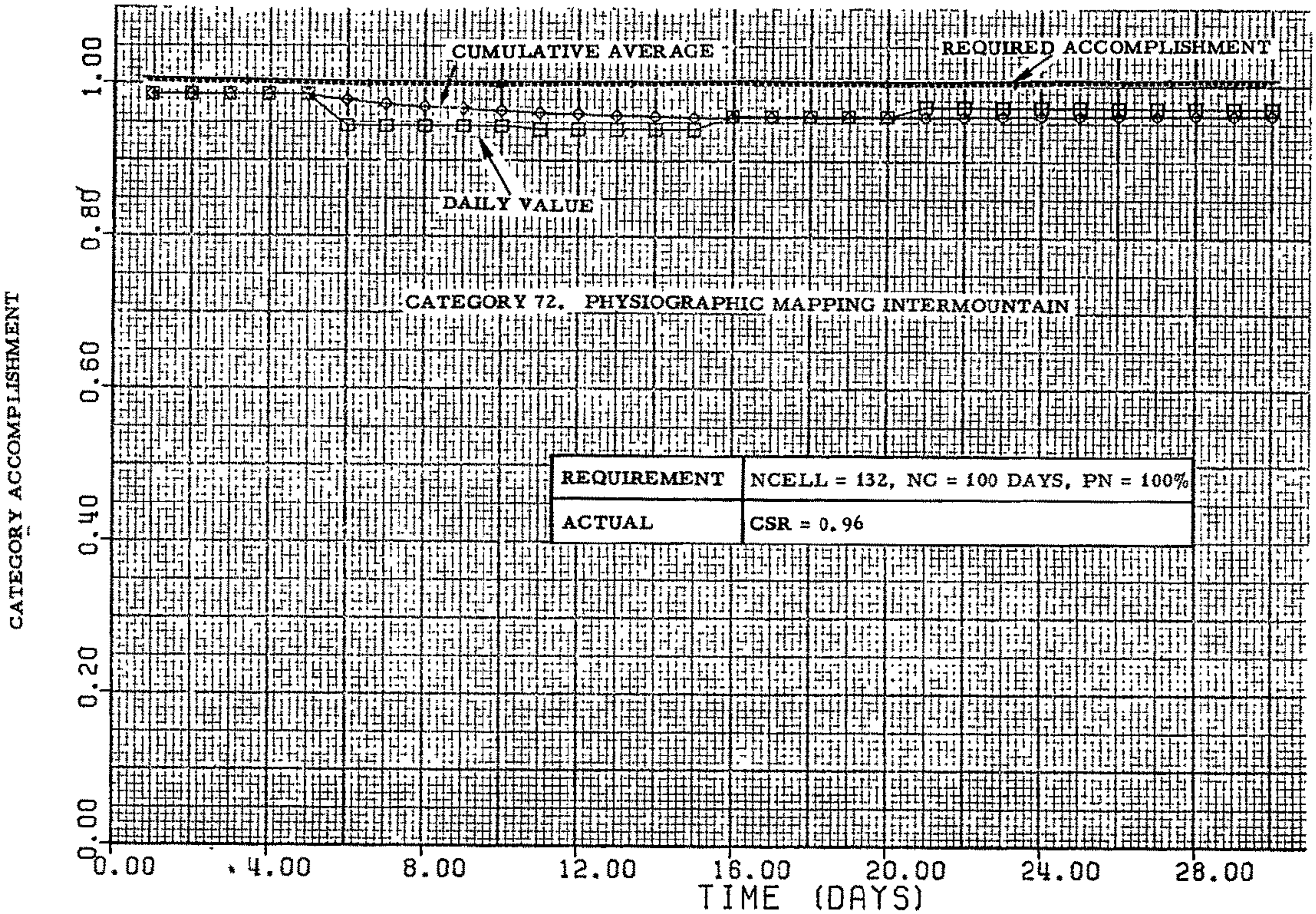


Figure 11. Category Accomplishment Profile (Typical 'M' Category)

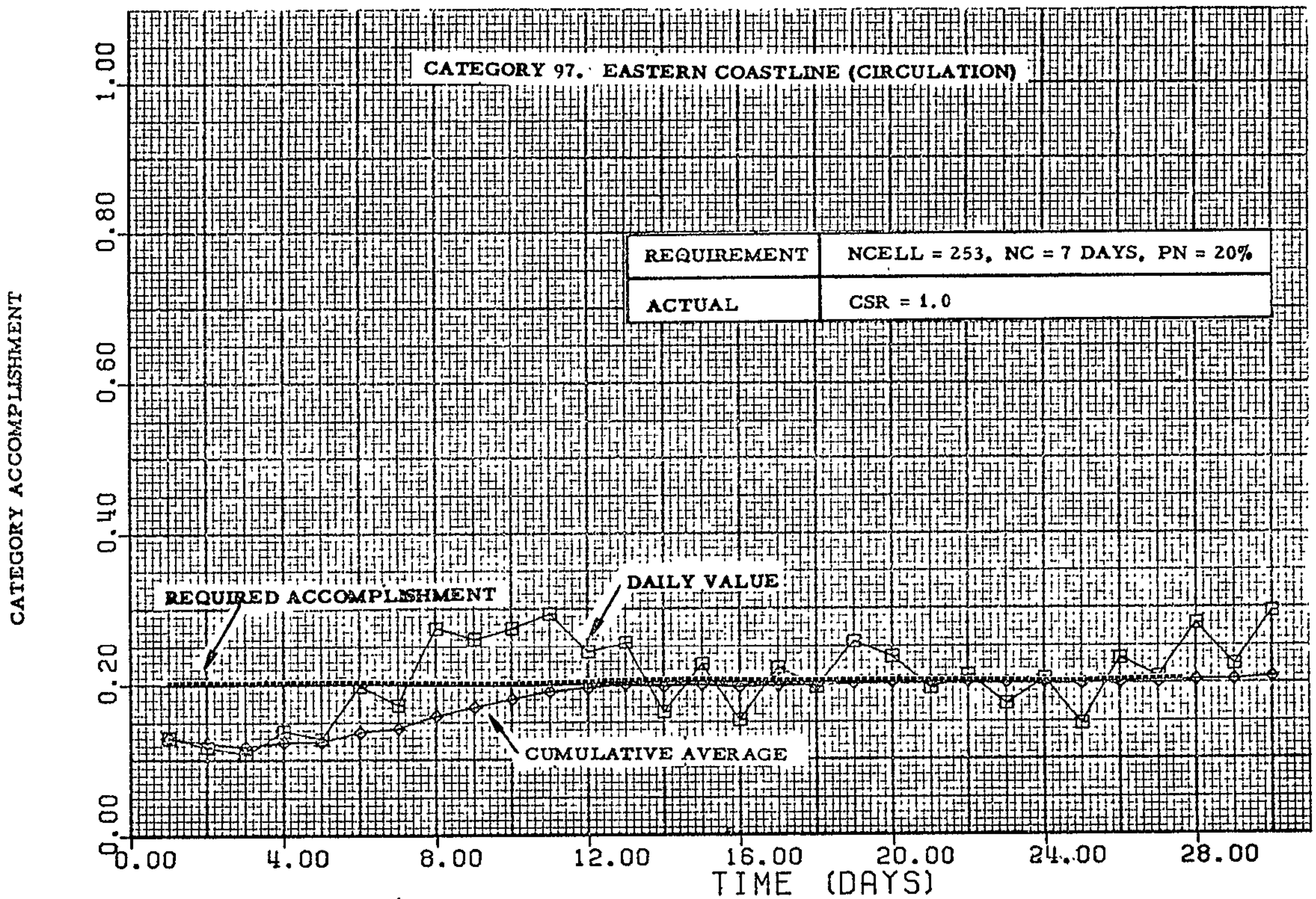


Figure 12. Category Accomplishment Profile (CSR ≥1.0)

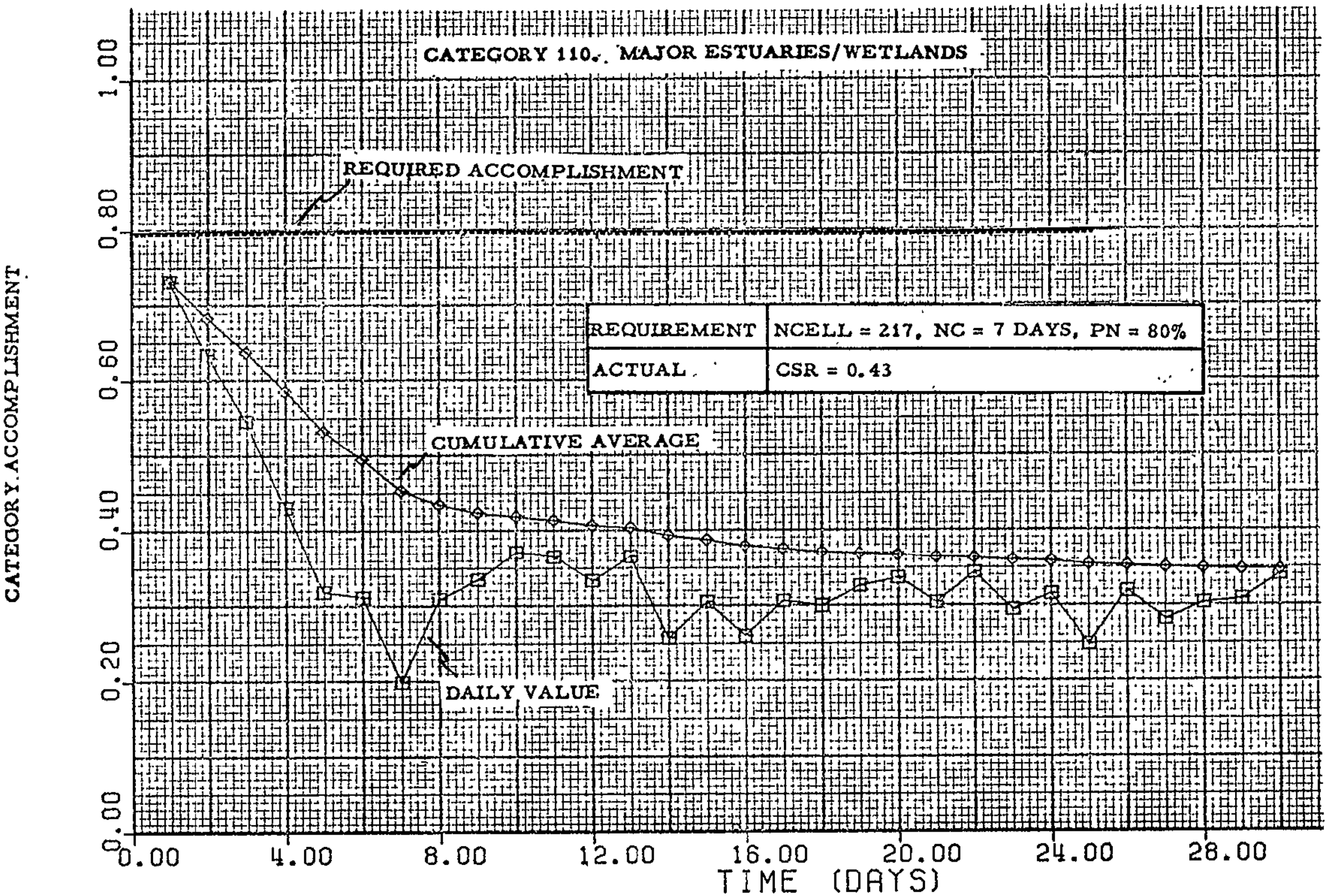


Figure 13. Category Accomplishment Profile (CSR <1.0)

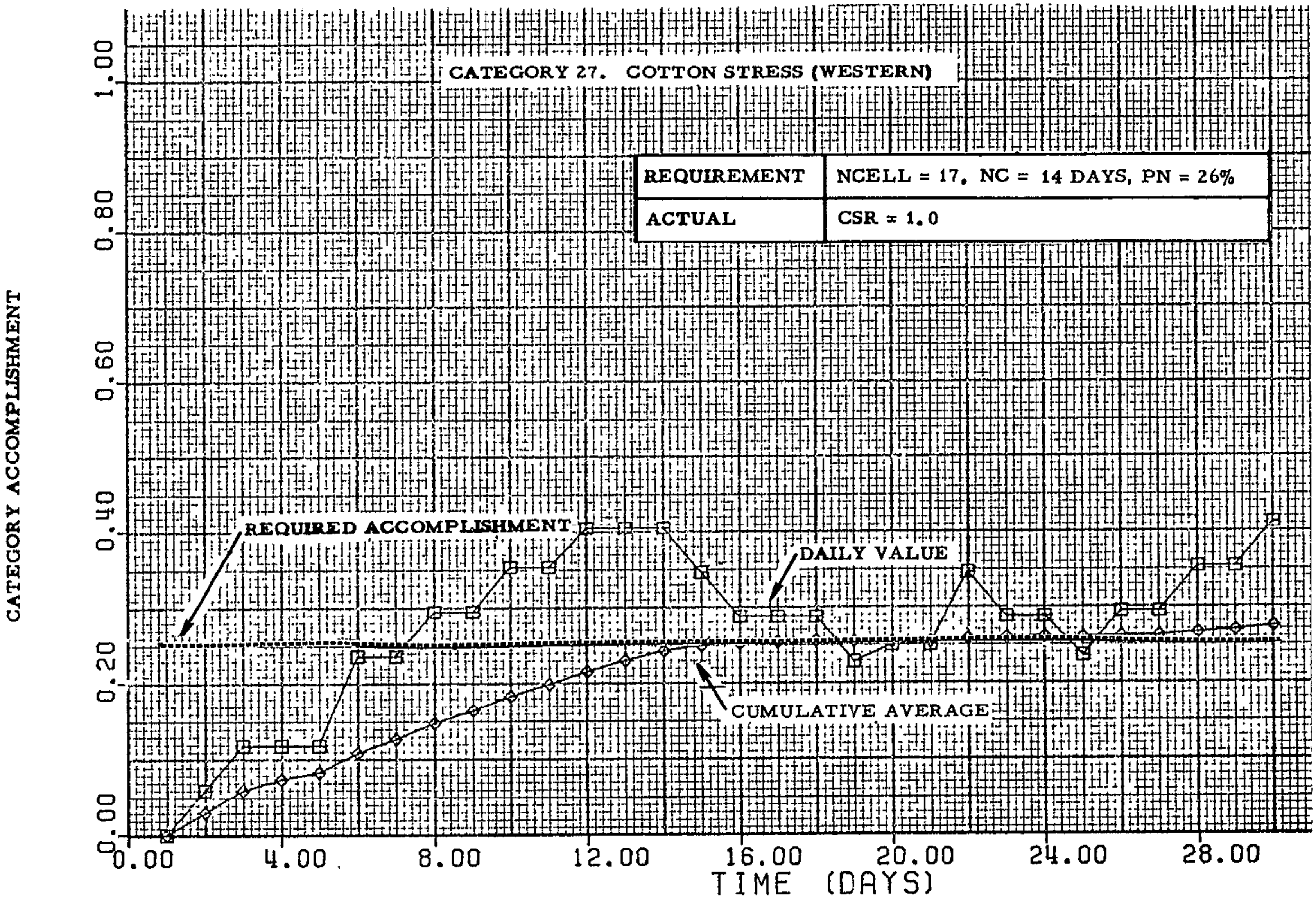


Figure 14. Category Accomplishment Profile (Initial Accomplishment = 0)

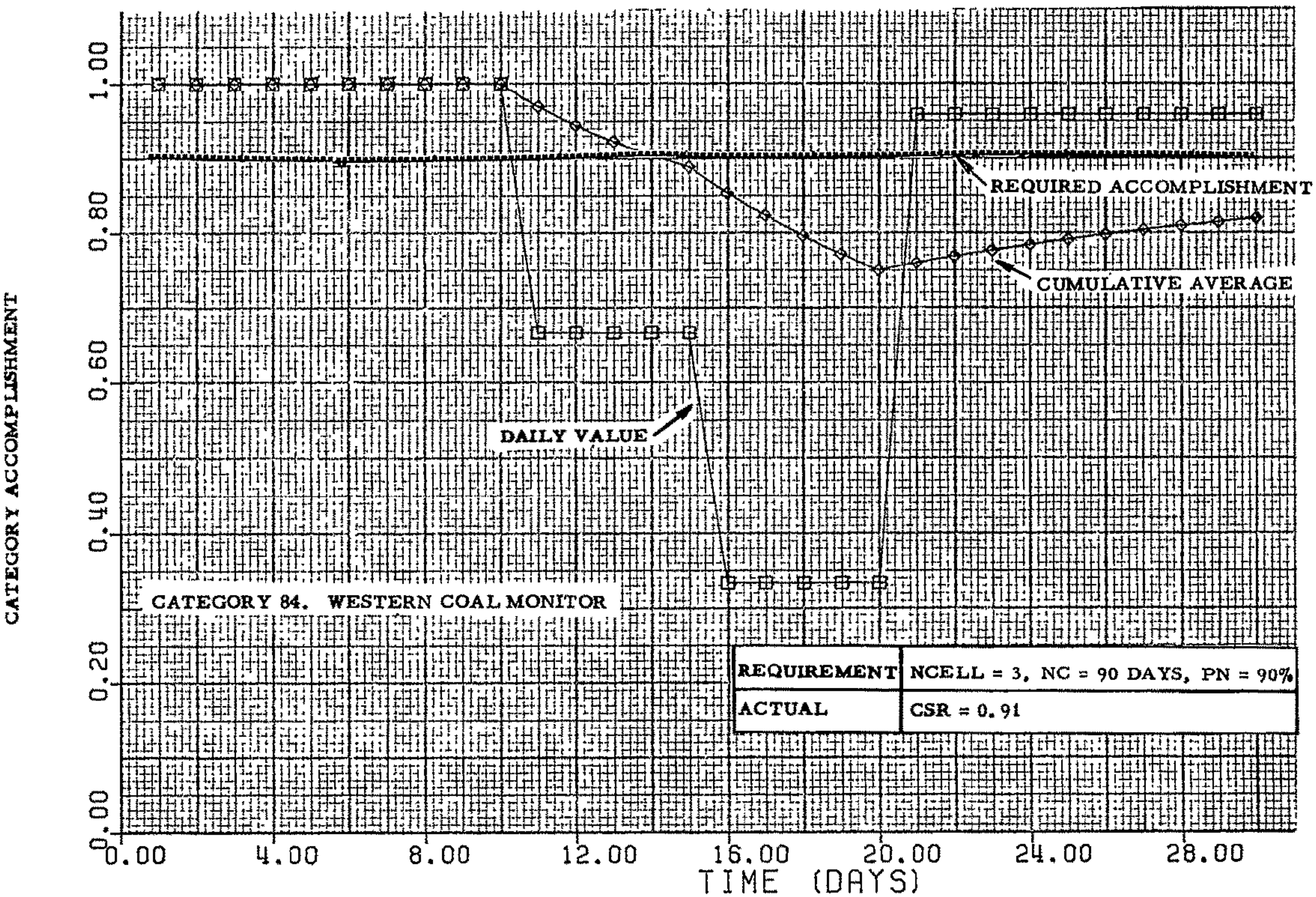


Figure 15. Category Accomplishment Profile (Small Sample Category)

5.0 COMPUTER OUTPUT EXAMPLE

Figures 16 to 19 present typical computer printouts from the EOS mission simulation runs. These types of outputs are printed for each day of the run. The printouts shown are the results of the EOS mission on the thirtieth day of March.

In Figure 16 the category status display is exhibited. There are thirteen columns of data in this printout and each is identified with a heading. The definition of each column is as follows:

CAT	-	Category number. This is a list of the active categories for March. There were 59.
SAMPLE PERIOD	-	Category cycle period requirement. Each category has a requirement that a certain percentage (PN) of the category area must be imaged within a certain number of days (NC). This is referred to as the sample period or nominal cycle period (NC) of the category.
NO. SITES	-	Total number of cells that represent the category area.
STATED REQMT.	-	Category percent coverage requirement. This is the percentage (PN) defined above (sample period). The actual printout of this data must be multiplied by 100 to transform it into percent. For example, category 28 has a stated requirement of 80 percent.
ACCOMP STATUS	-	Fraction of the category area that has been clearly imaged within the last "NC" days as of the beginning of the present day. The ACCOMP status can be compared directly with the Stated Requirements of the previous column to determine

how well the category is meeting its requirement.

ERROR - Proportional to the stated requirement minus the ACCOMP status. A positive value means the category is under-accomplishing its requirements. A negative value indicates over-accomplishment. These error values are used in the program to determine if the category weight (selection priority) should be increased or decreased. This computation pertains to the HRPI sensor only.

RAW CAT WEIGHT - Fixed intrinsic weight assigned to a category to initialize its selection priority relative to other categories. In this simulation, the raw category weights were set equal to 1.0, 5.0, and 50.0 for the class "M", "E" and "H" categories, respectively.

FINAL CAT WEIGHT - Raw category weight times the category weight mentioned above (ERROR). This weight value determines the selection priority of one category over another and varies from day to day according to how well a category is meeting its requirements.

ADJ REQMT - Adjustment of the stated requirement, if desired. For the March run, only category 110 was specified to adjust its stated requirement if necessary. This also is an automatic adjustment for the purpose of controlling sensor resource expenditure. It is impossible for the HRPI sensor to image 80 percent of its area within seven days, so its adjustment

requirement has been reduced to 40 percent. In this way, the HRPI will not concentrate its resource on attempting to meet the requirements of category 110 at the expense of other requirements.

DUE - Total number of cells in a category area not imaged within the last "NC" days.

ACCESSED - Number of category cells accessed during that particular day.

SELECTED - Number of category cells selected during that particular day (provided the category "NC" is 20 days or less). For categories with "NC's" greater than 20, their values listed under this column are actually a running sum of the selected cells over the past two or more days, depending on the magnitude of their "NC's." The number of days between updates is determined by the quantity

$$\left(\frac{NC-1}{20} + 1\right)_{INT}$$

This particular way of handling the sum of the selected cells minimizes computer bookkeeping storage.

UNIQUE RETURN - Number of cells in a category imaged free of clouds. The fact that certain parts of the imaged areas were cloudy to various degrees gives rise to the decimal portions of these values. Also, these values reflect imagery of one category picked up while imaging another category (bonus imagery) which, it should be pointed out, is not included in the previous column.

Values stated at the top of Figure 16 are simply the total of the values in the columns indicated. The "P" factor printed at the top is

an indicator of the overall accomplishment of the active categories on that particular day. The negative value, -0.5, indicates that, on this particular day, the categories, on the average, are slightly under-accomplishing their requirements. The weighting algorithm will automatically attempt to rectify the situation on the following day.

Figure 17 presents the statistical access data per category for the thirtieth day of March. This printout has ten columns of data defined as follows:

CAT	-	Category number
SITE ABS	-	Total number of category cells accessed on all revolutions on that day.
PVT	-	Same as the previous column, except that these access totals do not include cells which were accessed by the HRPI on a particular revolution and were imaged by the mapper on some previous revolution on that day.
WT	-	Resulting number of category cells after the totals of the previous column were filtered of those sites completely obscured by cloud cover.
REL	-	Resulting number of category cells after the totals of the previous column were filtered by reason of certain imaging constraints.
SITE SEL	-	Resulting number of category cells selected from the previous column for imaging by the sensors.
SITE VER	-	Number of category site points from the previous column verified as imaged under clear weather conditions.

The last three columns are various ratios of certain values in one column over the values in another column, and are rasily identified by the headings. For example, the values under the "SEL/ABS" column are the results of taking the numbers in the "SITE SEL" column and dividing by the numbers in the "SITE ABS" column. The sum totals of all the columns of data are given at the bottom of the printout.

In Figure 18, a typical printout of an age distribution for a category is given. The distribution shown is for category 38 at the end of the thirtieth day of March. These distributions are updated each day. Three columns of data are printed out. The values in the first column are the number of days counting back in time from the starting day indicated at the top of the printout; in the case shown, the thirtieth of March. The values in the second column are the fractions of the category areas imaged on the days indicated by the corresponding values in the first column. The third column is the accumulation sum of the second column. The average age printed at the bottom was computed by multiplying the values in column one by their corresponding values in column two and summing the results.

Figure 19 presents an example of a weather statistics printout from the computer program. The printout gives the cloud freeness statistics from day one to day thirty of March for the mapper and the HRPI sensors. This is a partial printout showing only a number of active categories on a single page of printout. This type of data is output for each day as well as output for the accumulation of data up to that day. On the printout, each category listed on the left is associated with two rows of data; one row lists the number of accessed cells under certain cloud-free conditions, and the other lists the number of selected (imaged) cells under those cloud-free conditions. The numbers ranging from zero to eight at the top of the printout identify equal increments of cloud conditions, zero being perfectly cloudy and eight being perfectly clear. The total number of cells accessed and selected for each active category for the month is given for additional information in the last column of the printout.

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 – 30

I-2 FINAL CATEGORY STATUS DISPLAY AT END OF DAY 30

MAR 1, 1967 P=-0.500 1908.27 SITES UNIQUE RETURN FROM 3278.00 SELECTED
5640.97 DUE 2604.00 ACCESSED

SAMPLED CATEGORIES

CAT	SAMPLE PERIOD	NO. SITES	STATED REQMT	ACCOMP STATUS	ERROR	RAW CAT WEIGHT	FINAL CAT WEIGHT	ADJ REQMT	DUE	ACCESSED	SELECTED	UNIQUE RETURN
28	90	222	0.80	0.735	0.065	5.000	9.023	0.800	58.885	86.000	42.000	32.937
38	14	75	0.48	0.500	-0.020	50.000	48.595	0.480	37.531	33.000	4.000	3.125
39	90	5826	0.90	0.878	0.022	5.000	4.692	0.900	711.573	1063.000	1595.000	997.973
40	30	1208	0.90	0.704	0.196	1.000	1.589	0.900	356.985	125.000	133.000	52.469
41	14	30	0.50	0.355	0.145	1.000	1.234	0.500	19.343	0.0	0.0	0.0
42	100	276	0.71	0.903	-0.193	5.000	2.500	0.710	26.756	74.000	69.000	44.828
43	100	3	0.45	0.625	-0.175	50.000	31.251	0.450	1.125	1.000	0.0	0.0
46	100	243	0.71	0.887	-0.177	5.000	2.500	0.710	27.418	47.000	59.000	43.125
47	100	3	0.39	0.957	-0.567	50.000	25.000	0.390	0.129	0.0	0.0	0.875
50	100	211	0.71	0.890	-0.180	5.000	2.500	0.710	23.215	37.000	42.000	25.406
51	100	4	0.45	0.656	-0.206	50.000	58.658	0.450	1.375	0.0	0.0	0.0
54	100	57	0.71	0.841	-0.131	5.000	2.500	0.710	9.038	3.000	28.000	16.094
55	100	2	0.22	0.927	-0.707	50.000	25.000	0.220	0.146	0.0	1.000	0.875
58	7	2585	0.25	0.180	0.070	1.000	1.045	0.250	2119.191	148.000	148.000	62.234
62	7	880	0.25	0.212	0.038	5.000	4.615	0.250	693.439	296.000	71.000	33.453
65	100	132	1.00	0.854	0.146	1.000	1.167	1.000	19.328	3.000	26.000	12.875
66	100	227	1.00	0.877	0.123	1.000	1.178	1.000	27.844	17.000	43.000	20.375
67	100	237	1.00	0.870	0.130	1.000	1.124	1.000	30.890	4.000	64.000	20.734
68	100	245	1.00	0.900	0.100	1.000	1.094	1.000	24.378	0.0	47.000	17.875
69	100	222	1.00	0.906	0.094	1.000	1.078	1.000	20.777	16.000	52.000	14.250
70	100	124	1.00	0.893	0.107	1.000	1.128	1.000	13.210	31.000	56.000	23.625
71	100	128	1.00	0.862	0.138	1.000	1.170	1.000	17.668	11.000	29.000	15.359
72	100	132	1.00	0.886	0.114	1.000	1.105	1.000	15.043	0.0	42.000	22.750
73	100	87	1.00	0.923	0.077	1.000	1.058	1.000	6.717	0.0	21.000	14.875
74	100	91	1.00	0.813	0.187	1.000	1.238	1.000	16.984	0.0	29.000	10.875
75	100	15	0.84	0.919	-0.079	50.000	35.829	0.840	1.219	5.000	2.000	3.875
76	100	34	0.51	0.868	-0.358	5.000	2.500	0.510	4.496	7.000	8.000	3.875
77	90	9	0.90	0.991	-0.091	50.000	40.645	0.900	0.082	3.000	2.000	2.250

Figure 16. Final Category Status Display at End of Day 30

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 - 30

78	100	124	0.72	0.901	-0.181	5.000	2.500	0.720	12.279	27.000	46.000	30.125
79	90	9	0.90	0.874	0.026	50.000	83.580	0.900	1.132	3.000	3.000	2.750
80	100	4	0.84	1.000	-0.160	50.000	25.000	0.840	0.0	0.0	0.0	0.0
81	100	104	0.84	0.833	0.007	5.000	4.472	0.840	17.326	39.000	35.000	20.594
82	90	3	0.90	0.667	0.233	50.000	48.252	0.900	1.000	2.000	0.0	0.0
83	100	204	0.84	0.856	-0.016	5.000	4.370	0.840	29.395	87.000	55.000	32.844
84	90	3	0.90	0.708	0.192	50.000	73.220	0.900	0.875	2.000	1.000	0.750
85	100	93	0.84	0.850	-0.010	5.000	4.054	0.840	13.923	40.000	30.000	16.406
86	100	2	0.91	0.875	0.035	50.000	84.726	0.910	0.250	2.000	1.000	0.875
87	100	453	0.84	0.830	0.010	5.000	4.737	0.840	76.914	80.000	160.000	86.031
88	100	6	0.91	0.729	0.181	50.000	87.823	0.910	1.625	2.000	3.000	2.750
89	100	117	0.72	0.857	-0.137	5.000	2.500	0.720	16.787	59.000	50.000	24.000
90	90	13	0.80	0.827	-0.027	50.000	25.000	0.800	2.250	1.000	1.000	2.000
92	100	71	0.83	0.786	0.044	1.000	0.967	0.830	15.207	0.0	21.000	10.625
94	30	485	0.70	0.683	0.017	50.000	59.245	0.700	153.509	66.000	9.000	26.125
95	90	8	1.00	0.770	0.230	1.000	1.474	1.000	1.844	0.0	0.0	0.0
96	90	253	0.50	0.613	-0.113	1.000	1.204	0.500	97.804	0.0	77.000	42.000
97	7	253	0.20	0.269	-0.069	50.000	25.000	0.200	164.885	6.000	1.000	4.375
98	90	4	0.95	0.973	-0.023	50.000	55.578	0.950	0.109	0.0	0.0	0.0
99	90	106	0.80	0.885	-0.085	1.000	0.809	0.800	12.162	0.0	0.0	0.0
100	7	106	0.30	0.201	0.099	50.000	66.513	0.300	84.655	35.000	2.000	7.625
101	90	1	0.95	1.000	-0.050	50.000	45.261	0.950	0.0	1.000	0.0	0.875
102	90	157	0.50	0.762	-0.262	1.000	0.500	0.500	37.383	6.000	31.000	11.875
103	7	157	0.20	0.152	0.048	50.000	58.747	0.200	133.123	45.000	1.000	4.000
104	90	3	0.95	0.979	-0.029	50.000	29.389	0.950	0.063	1.000	0.0	0.0
105	90	197	0.50	0.896	-0.396	1.000	0.500	0.500	20.488	0.0	42.000	31.125
106	7	197	0.20	0.274	-0.074	50.000	25.000	0.200	142.996	16.000	3.000	9.188
107	90	2	0.95	0.999	-0.049	50.000	56.594	0.950	0.002	0.0	0.0	0.0
108	90	260	0.80	0.481	0.319	1.000	2.447	0.800	134.833	33.000	86.000	24.250
110	7	217	0.80	0.273	0.127	50.000	87.012	0.400	157.821	35.000	3.000	9.375
111	100	47	0.94	0.879	0.061	50.000	68.204	0.940	5.678	6.000	4.000	10.719

Figure 16. Final Category Status Display at End of Day 30 (cont'd)

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 - 30

D-11 STATISTICAL PER-CATEGORY ACCESS DATA FOR DAY 30

CAT	SITE ABS	AFTER FILTERING PVT	WT	REL	SITE SEL	SITE VER	SEL/ ABS	VER/ ABS	VER/ SEL
28	522.00	462.00	239.00	210.00	42.00	20.75	0.08	0.04	0.49
38	49.00	49.00	33.00	33.00	4.00	3.13	0.08	0.06	0.78
39	13949.00	11358.00	7101.00	6225.00	1595.00	731.63	0.11	0.05	0.46
40	195.00	195.00	133.00	133.00	133.00	47.75	0.68	0.24	0.36
41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
42	584.00	475.00	295.00	262.00	69.00	35.75	0.12	0.06	0.52
43	4.00	4.00	2.00	2.00	0.0	0.0	0.0	0.0	0.0
46	601.00	506.00	281.00	218.00	59.00	27.88	0.10	0.05	0.47
47	4.00	4.00	3.00	3.00	0.0	0.0	0.0	0.0	0.0
50	472.00	411.00	246.00	209.00	42.00	21.13	0.09	0.04	0.50
51	7.00	7.00	3.00	3.00	0.0	0.0	0.0	0.0	0.0
54	167.00	116.00	72.00	72.00	28.00	11.88	0.17	0.07	0.42
55	5.00	4.00	3.00	3.00	1.00	0.88	0.20	0.17	0.88
58	255.00	255.00	148.00	148.00	148.00	60.50	0.58	0.24	0.41
62	611.00	541.00	335.00	296.00	71.00	25.13	0.12	0.04	0.35
65	39.00	39.00	26.00	26.00	26.00	11.88	0.67	0.30	0.46
66	112.00	112.00	43.00	43.00	43.00	18.63	0.38	0.17	0.43
67	119.00	119.00	64.00	64.00	64.00	20.50	0.54	0.17	0.32
68	70.00	70.00	47.00	47.00	47.00	17.88	0.67	0.26	0.38
69	94.00	94.00	52.00	52.00	52.00	14.25	0.55	0.15	0.27
70	65.00	65.00	56.00	56.00	56.00	23.50	0.86	0.36	0.42
71	58.00	58.00	29.00	29.00	29.00	14.63	0.50	0.25	0.50
72	51.00	51.00	42.00	42.00	42.00	22.38	0.82	0.44	0.53
73	36.00	36.00	21.00	21.00	21.00	14.88	0.58	0.41	0.71
74	57.00	57.00	29.00	29.00	29.00	10.88	0.51	0.19	0.38
75	30.00	28.00	21.00	21.00	2.00	2.00	0.07	0.07	1.00
76	84.00	69.00	39.00	35.00	8.00	3.00	0.10	0.04	0.38
77	20.00	19.00	14.00	14.00	2.00	1.50	0.10	0.07	0.75
78	318.00	239.00	175.00	165.00	46.00	26.75	0.14	0.08	0.58
79	21.00	18.00	14.00	14.00	3.00	1.75	0.14	0.08	0.58
80	8.00	8.00	8.00	8.00	0.0	0.0	0.0	0.0	0.0
81	284.00	227.00	132.00	124.00	35.00	15.75	0.12	0.06	0.45

Figure 17. Category Statistical Data Summary

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 - 30

82	6.00	6.00	3.00	3.00	0.0	0.0	0.0	0.0	0.0
83	518.00	442.00	291.00	247.00	55.00	24.50	0.11	0.05	0.45
84	7.00	7.00	5.00	5.00	1.00	0.75	0.14	0.11	0.75
85	295.00	238.00	111.00	104.00	30.00	8.13	0.10	0.03	0.27
86	4.00	4.00	2.00	2.00	1.00	0.88	0.25	0.22	0.88
87	1131.00	918.00	593.00	516.00	160.00	60.13	0.14	0.05	0.38
88	14.00	12.00	10.00	10.00	3.00	2.75	0.21	0.20	0.92
89	340.00	253.00	196.00	164.00	50.00	20.38	0.15	0.06	0.41
90	29.00	27.00	15.00	13.00	1.00	0.88	0.03	0.03	0.88
92	29.00	29.00	21.00	21.00	21.00	10.63	0.72	0.37	0.51
94	321.00	321.00	186.00	183.00	9.00	6.50	0.03	0.02	0.72
95	3.00	3.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
96	115.00	115.00	77.00	77.00	77.00	42.00	0.67	0.37	0.55
97	17.00	17.00	6.00	6.00	1.00	0.88	0.06	0.05	0.88
98	8.00	8.00	6.00	5.00	0.0	0.0	0.0	0.0	0.0
99	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100	36.00	36.00	35.00	35.00	2.00	1.50	0.06	0.04	0.75
101	1.00	1.00	1.00	1.00	0.0	0.0	0.0	0.0	0.0
102	61.00	61.00	31.00	31.00	31.00	11.88	0.51	0.19	0.38
103	67.00	67.00	51.00	45.00	1.00	1.00	0.01	0.01	1.00
104	5.00	5.00	4.00	3.00	0.0	0.0	0.0	0.0	0.0
105	52.00	52.00	42.00	42.00	42.00	30.25	0.81	0.58	0.72
106	36.00	36.00	16.00	16.00	3.00	2.00	0.08	0.06	0.67
107	4.00	4.00	2.00	2.00	0.0	0.0	0.0	0.0	0.0
108	141.00	141.00	86.00	86.00	86.00	24.13	0.61	0.17	0.28
110	56.00	56.00	40.00	35.00	3.00	2.38	0.05	0.04	0.79
111	80.00	79.00	63.00	62.00	4.00	2.38	0.05	0.03	0.59
TOTALS	22267.00	18634.00	11599.00	10321.00	3278.00	1460.38	0.15	0.07	0.45

Figure 17. Category Statistical Data Summary (cont'd)

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                              PREDICTOR PROGRAM
....................EOS MISSION SIMULATION * MAR 21 - 30.....................

                    0-6  CATEGORY AGE DISTRIBUTION
                              END OF DAY  30

              CAT.   38 - GRASSLANDS  STRESS MONITOR
               AGE      FRACTION OF CATEGORY      CUM FRACTION
                 1            0.042                   0.042
                 2            0.040                   0.082
                 3            0.053                   0.135
                 4            0.048                   0.183
                 5            0.015                   0.198
                 6            0.077                   0.275
                 7            0.017                   0.292
                 8            0.051                   0.342
                 9            0.0                     0.342
                10            0.051                   0.393
                11            0.013                   0.407
                12            0.054                   0.461
                13            0.033                   0.494
                14            0.034                   0.528
                15            0.010                   0.538
                16            0.001                   0.539
                17            0.019                   0.558
                18            0.013                   0.571
                19            0.013                   0.584
                20            0.0                     0.584
                21            0.033                   0.616
                22            0.013                   0.630
                23            0.036                   0.666
                24            0.000                   0.666
                25            0.014                   0.680
                26            0.038                   0.718
                27            0.004                   0.722
                28            0.058                   0.780
                29            0.0                     0.780
                30            0.039                   0.820
                31            0.180                   1.000
               AVERAGE AGE   16.375

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Figure 18. Typical Category Age Distribution

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 - 30

CUMULATIVE THROUGH DAY 30 WEATHER STATISTICS

MAPPER SENSOR

CAT		CLOUD FREENESS (EIGHTHS) 0	1	2	3	4	5	6	7	8	TOTAL
28	ACCESSED	194.00	73.00	74.00	8.00	35.00	51.00	14.00	56.00	46.00	551.00
	SELECTED	0.0	73.00	74.00	8.00	35.00	51.00	14.00	56.00	46.00	357.00
39	ACCESSED	4239.00	2440.00	1465.00	1325.00	949.00	977.00	910.00	1182.00	1155.00	14642.00
	SELECTED	0.0	2440.00	1465.00	1325.00	949.00	977.00	910.00	1182.00	1155.00	10403.00
40	ACCESSED	778.00	498.00	311.00	394.00	240.00	274.00	232.00	231.00	294.00	3252.00
	SELECTED	0.0	483.00	304.00	387.00	233.00	264.00	227.00	224.00	286.00	2408.00
41	ACCESSED	18.00	12.00	11.00	4.00	8.00	5.00	4.00	7.00	4.00	73.00
	SELECTED	0.0	12.00	11.00	3.00	7.00	5.00	4.00	7.00	4.00	53.00
42	ACCESSED	155.00	101.00	114.00	33.00	48.00	28.00	25.00	95.00	53.00	652.00
	SELECTED	0.0	101.00	114.00	33.00	48.00	28.00	25.00	95.00	53.00	497.00
46	ACCESSED	237.00	109.00	43.00	65.00	20.00	19.00	63.00	23.00	50.00	629.00
	SELECTED	0.0	109.00	43.00	65.00	20.00	19.00	63.00	23.00	50.00	392.00
50	ACCESSED	156.00	74.00	66.00	29.00	38.00	57.00	29.00	37.00	34.00	520.00
	SELECTED	0.0	74.00	66.00	29.00	38.00	57.00	29.00	37.00	34.00	364.00
54	ACCESSED	55.00	31.00	14.00	18.00	7.00	4.00	0.0	20.00	0.0	149.00
	SELECTED	0.0	31.00	14.00	18.00	7.00	4.00	0.0	20.00	0.0	94.00
58	ACCESSED	1952.00	1025.00	623.00	465.00	405.00	404.00	509.00	450.00	582.00	6415.00
	SELECTED	0.0	992.00	601.00	454.00	388.00	392.00	498.00	441.00	563.00	4329.00
62	ACCESSED	776.00	417.00	267.00	343.00	148.00	115.00	82.00	145.00	145.00	2438.00
	SELECTED	0.0	417.00	267.00	343.00	148.00	115.00	82.00	145.00	145.00	1662.00
65	ACCESSED	152.00	74.00	31.00	22.00	18.00	13.00	9.00	19.00	18.00	356.00
	SELECTED	0.0	73.00	31.00	21.00	18.00	12.00	9.00	19.00	17.00	200.00
66	ACCESSED	191.00	82.00	68.00	29.00	20.00	61.00	36.00	48.00	40.00	575.00
	SELECTED	0.0	79.00	64.00	28.00	18.00	60.00	34.00	44.00	39.00	366.00
67	ACCESSED	217.00	119.00	69.00	35.00	41.00	16.00	21.00	57.00	30.00	605.00
	SELECTED	0.0	116.00	68.00	35.00	40.00	15.00	19.00	57.00	30.00	380.00
68	ACCESSED	94.00	98.00	76.00	31.00	44.00	62.00	57.00	33.00	52.00	547.00
	SELECTED	0.0	96.00	76.00	30.00	43.00	61.00	57.00	33.00	52.00	448.00
69	ACCESSED	134.00	110.00	68.00	63.00	49.00	49.00	46.00	51.00	20.00	590.00
	SELECTED	0.0	103.00	66.00	62.00	47.00	49.00	46.00	50.00	20.00	443.00
70	ACCESSED	36.00	69.00	26.00	30.00	31.00	23.00	21.00	42.00	35.00	313.00
	SELECTED	0.0	68.00	26.00	30.00	31.00	23.00	21.00	42.00	34.00	275.00

Figure 19a. Weather Statistics for Mapper Sensor

PREDICTOR PROGRAM

EOS MISSION SIMULATION * MAR 21 - 30

CUMULATIVE THROUGH DAY 30 WEATHER STATISTICS

HRPI SENSOR

CAT		CLOUD FREENESS (EIGHTHS) 0	1	2	3	4	5	6	7	8	TOTAL
28	ACCESSED	780.00	223.00	215.00	182.00	108.00	154.00	57.00	140.00	136.00	1995.00
	SELECTED	0.0	1.00	0.0	1.00	0.0	3.00	3.00	4.00	4.00	16.00
38	ACCESSED	230.00	144.00	101.00	83.00	73.00	75.00	47.00	77.00	80.00	910.00
	SELECTED	0.0	2.00	3.00	10.00	10.00	13.00	16.00	24.00	41.00	119.00
39	ACCESSED	18666.00	7228.00	4775.00	4202.00	3553.00	3546.00	2474.00	3624.00	3928.00	51996.00
	SELECTED	0.0	9.00	13.00	36.00	29.00	42.00	69.00	84.00	107.00	389.00
42	ACCESSED	702.00	315.00	215.00	189.00	220.00	194.00	90.00	218.00	149.00	2292.00
	SELECTED	0.0	2.00	1.00	1.00	5.00	3.00	3.00	11.00	6.00	32.00
43	ACCESSED	13.00	5.00	2.00	1.00	3.00	5.00	1.00	2.00	2.00	34.00
	SELECTED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46	ACCESSED	1051.00	278.00	157.00	172.00	97.00	122.00	142.00	107.00	241.00	2367.00
	SELECTED	0.0	0.0	0.0	0.0	0.0	1.00	2.00	2.00	3.00	8.00
47	ACCESSED	7.00	10.00	1.00	4.00	2.00	1.00	4.00	5.00	1.00	35.00
	SELECTED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
50	ACCESSED	704.00	235.00	184.00	146.00	105.00	123.00	85.00	99.00	143.00	1824.00
	SELECTED	0.0	0.0	0.0	1.00	0.0	0.0	3.00	2.00	3.00	9.00
51	ACCESSED	19.00	8.00	7.00	3.00	2.00	1.00	1.00	3.00	1.00	45.00
	SELECTED	0.0	0.0	0.0	1.00	0.0	0.0	1.00	0.0	1.00	3.00
54	ACCESSED	210.00	122.00	74.00	25.00	37.00	53.00	5.00	27.00	12.00	565.00
	SELECTED	0.0	2.00	0.0	2.00	0.0	1.00	0.0	3.00	0.0	8.00
55	ACCESSED	8.00	4.00	3.00	2.00	0.0	1.00	1.00	2.00	2.00	23.00
	SELECTED	0.0	0.0	0.0	2.00	0.0	1.00	0.0	1.00	1.00	5.00
62	ACCESSED	3996.00	1480.00	956.00	813.00	631.00	582.00	345.00	599.00	648.00	10050.00
	SELECTED	0.0	2.00	2.00	7.00	9.00	7.00	15.00	19.00	19.00	80.00
75	ACCESSED	59.00	33.00	12.00	18.00	16.00	5.00	6.00	10.00	14.00	173.00
	SELECTED	0.0	0.0	0.0	2.00	1.00	0.0	1.00	1.00	4.00	9.00
76	ACCESSED	152.00	40.00	33.00	16.00	12.00	16.00	21.00	14.00	27.00	331.00
	SELECTED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
77	ACCESSED	31.00	21.00	9.00	9.00	6.00	6.00	7.00	5.00	9.00	103.00
	SELECTED	0.0	1.00	2.00	3.00	0.0	2.00	2.00	2.00	1.00	13.00
78	ACCESSED	458.00	155.00	61.00	89.00	78.00	81.00	29.00	81.00	121.00	1153.00
	SELECTED	0.0	0.0	0.0	1.00	1.00	0.0	1.00	1.00	0.0	4.00

Figure 19b. Weather Statistics for HRPI Sensor